ELEMENTARY PSYCHOLOGY

THE MACMILLAN COMPANY
NEW YORK · BOSTON · CHICAGO · DALLAS
ATLANTA · SAN FRANCISCO

MACMILLAN & CO., LIMITED
LONDON · BOMBAY · CALCUTTA
MELBOURNE

THE MACMILLAN CO. OF CANADA, LTD.
TORONTO

ELEMENTARY PSYCHOLOGY

BY

ARTHUR I. GATES

PROFESSOR OF EDUCATIONAL PSYCHOLOGY, TEACHERS COLLEGE, COLUMBIA UNIVERSITY

New York

THE MACMILLAN COMPANY

1926

Set up and electrotyped.
Published September, 1925.
Reprinted..........November, 1925.
Reprinted.........April, 1926.
Reprinted..........September, 1926.

L. H. JENKINS, INC.
RICHMOND, VIRGINIA

PREFACE

This book has been written to meet numerous requests for an elementary textbook of psychology for the general student similar in type to my *Psychology for Students of Education.* Although this new book resembles the earlier work in point of view and organization, it differs greatly in content and application. Many topics found in the first book have been omitted entirely and many new ones added. The present work contains a much more extensive account of the introspective studies of conscious states and processes, both simple and complex. The discussion of the instinct theory and its applications has been rewritten entirely to fit more adequately the needs of a general critical course. The chapters on learning in complex functions, on economical methods of learning, on perception, reasoning and imagination, have been greatly changed. The treatments of individual differences and mental measurements have been rewritten to include illustrations from and applications to diverse fields of interest. Chapter III on the Connecting Mechanisms, Chapter X on The General Laws of Learning, and Chapter XVIII on Intelligence, have been less extensively modified.

The first part of the book deals with the physical basis of behavior and conscious activity, since, so far as I have been able to learn, instructors are mainly of the opinion that a clear, elementary account of these mechanisms is useful or essential as a preparation for many problems of psychology proper. The treatment of the receiving, connecting, and reacting mechanisms is schematic and brief. Attention is centered on the functions rather than the structures of these organs and only those facts are presented which bear upon the genuinely psychological problems that follow.

In the main body of the text, an effort has been made to state the facts of psychology in such a way as to represent without bias the important achievements of the past and the lines of study being followed at the present time. The results both of introspective and objective study have been utilized with equal freedom. The book is designed to be a survey rather than a system of psychology.

The book has been written with the limitations of the elementary student in mind. The method of development is of the spiral type. Certain important topics are touched upon first in the treatment of the physical basis of behavior, again under native equipment, again during discussion of adjustment and learning, and finally under individual differences. Technical terms and concise definitions have been used sparingly: an elementary text should be an exposition of facts rather than a dictionary of terms; students should be encouraged to understand and utilize ideas rather than to memorize definitions.

The book contains more practical applications than is usual in an introductory text. This method of illustrating the facts in terms of familiar experiences has been adopted deliberately since psychology has itself demonstrated that this is the best way to make the facts intelligible. The beginning student especially needs concrete illustrative detail. Not all of the principles and theories familiar to advanced students have been included. Some have been omitted because they are unimportant or unintelligible to students taking a first course and belong properly to advanced study.

Each chapter is followed by a series of questions and exercises sufficient in number and, I hope, adequate in character to stimulate through individual thinking and group discussion a more thorough understanding and utilization of the facts than is usually obtained through reading alone. In the first chapter are given samples of several types of test exercises and questions for review and application. These tests are not continued throughout the book for two reasons: the practice of making up such exercises for themselves is an excellent form

of study for students; and, for purposes of examination, the instructor may make up original lists more suited to his purposes and his students. In the last section of Chapter I other published series of questions and exercises for use in introductory courses are mentioned.

The references at the close of the chapters are of two types: "general references" and "references to studies utilized in the text." Each chapter concludes with a list of general references selected for the purpose of enabling the student or instructor to find readily other accounts, especially more extensive general treatments, of the topics under discussion. Those chapters which include summaries of the findings of, or statistical data from, particular studies contain references to these articles listed at the end. The student or instructor is thus enabled to find the sources of all data for purposes of verification or amplification of the account in the text.

Two methods of reference to authorities or sources of information in the body of the text have been adopted. The name of the authors of well-known discoveries or theories are printed in the usual manner. The names of authors of special studies are printed in parentheses, e.g., "Observation of recently born infants (by Watson) have disclosed——etc." At the end of the chapter, full reference to such a study is given. The names presented parenthetically may be considered not as items to be mastered by the student but merely as guides to further reading—unless the instructor decides otherwise.

I am grateful to Miss Helene Searcy, Miss Helen Thompson, and Miss Dorothy Van Alstyne for splendid assistance in the preparation of the manuscript and the reading of proof. My obligations are especially heavy to my wife, Dr. Georgina S. Gates, whose repeated critical readings of the manuscript have made possible improvements of many types.

I take pleasure in acknowledging the courtesy of the following authors and publishers for permission to adapt or reproduce illustrations: J. R. Angell, B. T. Baldwin, Breed and Shepherd, Cyril Burt, W. B. Cannon, June Downey, G. S. Gates, W. H. Howell, P. J. Kruse, M. Luckiesh, D. Starch,

L. I. Stecher, L. M. Terman, E. L. Thorndike, John Watson, D. Appleton and Company, Henry Holt and Company, Houghton Mifflin Company, P. S. King and Company (London), The Macmillan Company, D. van Nostrand and Company, W. B. Saunders and Company, The Teachers College Bureau of Publications and the World Book Company.

ARTHUR I. GATES.

Teachers College
Columbia University
May, 1925.

CONTENTS

ELEMENTARY PSYCHOLOGY

ELEMENTARY PSYCHOLOGY

CHAPTER I

THE METHODS AND SUBJECT MATTER OF PSYCHOLOGY

The subject matter of modern psychology consists mainly of a large number of problems concerning human behavior which, almost as far back as history is recorded, have engaged the attention of thoughtful men. Ancient warriors, priests and medicine men, as well as modern teachers, lawyers, preachers and salesmen attempt to understand as best they can by reflecting on their own impulses, feelings, ideas and acts, and by studying the behavior of others, the important characteristics of human conduct. Thus most people develop, in ways that to them seem reasonable, opinions concerning the motives that make people willing to buy or work or fight, that arouse suspicion, confidence or pleasure, that assuage envy, embarrassment or fear. Most people have acquired beliefs concerning the way the mind does and should work, concerning the causes of bad judgment and prejudice, the value of clear "mental pictures" or images, the means of improving memory or attention. We have explanations, too, for the differences in ability to learn which school children show, whether they are inborn or due to training, to the type of management or teaching

secured, whether they foretell similar failure or success in athletics, business or morals. We have adopted methods—not always clearly understood—of judging traits of body, mind and character, such as speed of movement, endurance, alertness, sensitiveness, sagacity, honesty, ambitiousness or sociability. We have theories concerning mental and temperamental differences between children and adults, men and women, Chinese and Negroes. We have acquired convictions concerning the effects of punishment and praise, of alcohol and tobacco, of the weather or noise, upon efficiency in learning or performing. The fact that several periodicals which give much space to such topics have attained wide circulation indicates that most people appreciate the value of the study of these problems. For a long time the subject of study by crude methods, these topics, together with many similar ones, when attacked by scientific methods constitute psychology. Since it is the method of study that is the essential feature by which psychology is to be distinguished from less accurate types of investigation, we should disclose at once the characteristics of the scientific method.

The Characteristics of the Scientific Method of Securing Reliable Observations.

The Scientific like Cruder Methods Depends on Observation.—The scientific investigator must, like any other person, secure his material by observing the activities of himself or others. Difficulties are here encountered at once since observation is rarely complete or fully accurate. This fact has been demonstrated in many tests. For example, a brief scene involving a quarrel which had been carefully rehearsed was performed before a group of forty professional men. Believing the quarrel genuine

and anticipating the use of their testimony in court the witnesses wrote out a full account. Thirteen of the forty observers failed to record as much as half of the important facts and the others had omitted from 20 to 50 per cent. In addition to the omissions, from 5 to 50 per cent of the statements which these professional men were willing to submit to a court of law, were erroneous.

Even when observers are aware of the types of errors usually made and when surprise and emotional disturbances are eliminated by means of warnings and instructions—conditions often fulfilled in class experiments in experimental psychology—glaring omissions and errors persist. Whether the object of observation is a section of a moving picture, or an object permitting more deliberate study such as a still picture, a stamp or a cigarette package the unreliability of ordinary observation is still apparent. It is pronounced when the objects of observation are facial expressions and bodily attitudes, eye or finger movements—witness the ease with which sleight-of-hand performers deceive us,—or mental images and other mental activities important to psychology. The scientific worker in psychology, then, must first of all attempt to increase the reliability of his observation.

The Scientific Method Seeks Means of Increasing the Reliability of Observation.—Inexperience and anticipation in the observer and complexity and brevity in the events observed are sources of error in the results. The scientific worker attempts to improve conditions in all of these respects.

Persistent training in observing the particular class of events is one requirement. That training, prolonged and controlled, does result in improvement is attested by results in many fields. Thus the expert musician hears overtones and false notes, the artist sees defects of per-

spective and color, the wine taster senses slight differences in taste and odor, the physician perceives symptoms of disease and health, the mariner sees evidences of storm or calm that are unobserved or inaccurately observed by the novice. Training in observation to be effective must be specific. The musician by increasing his ability to perceive in the field of sound becomes little if any more efficient in observing colors, symptoms of disease or of weather conditions. Thus for each science training is specific; indeed, even within the science, it must be highly specialized. The psychologist may become a proficient observer of the rapid start and stop movements of the eyes in reading without becoming a good witness of the facial expressions in emotions, of mental images or the mental states involved in reasoning. Since specialized training increases the fullness and accuracy of observations the scientific method demands trained observers.

Anticipation of results, which often springs from prejudice or a desire to secure evidence favoring a cherished belief or theory, is a stumbling block in science as in everyday life. Just as most people are unable to observe evidence of guilt in a person loved, and as persons attending a spiritualist's séance so often mistake a hazy illumination for the face of a departed friend whose image has been in mind, so scientific workers are likely to be influenced by desire and expectation. Against these sources of error, the scientific worker must rigidly school himself. He must acquire the "scientific attitude," that is, an open-minded, impersonal, unprejudiced attitude toward the facts observed. A few seem to be gifted with this attitude by nature, others acquire it only after prolonged and diligent effort. Provisions to secure unprejudiced observations are an important feature of the general methods of science.

Since observers, despite diligent training, are rarely absolutely accurate and sometimes misled by expectation or desire, the scientific method makes provision for repetition of observations. It is not sufficient that the investigator should repeat his own experiment, although this is desirable. Before the results of an observation are accepted, they must be repeated by others, usually many others. To this end, it is customary for the scientific worker to report in full, not only the results of his study, but also the conditions and procedures so that other investigators may set up an identical situation and repeat the observation. In this way, errors in observation, whether due to prejudice, oversight or other influences, may be detected. It will be observed that repetition of observations provides an opportunity for the investigator to check up his own work and thus learn to do it better, and the means by which scientific repute, good or poor, may be established.

Errors in observation arise not only because of prejudice and lack of training in the observer, but also because of unfavorable conditions. The essential features of good conditions are isolation of the facts to be observed and control of all other factors which may conceivably affect the results. To illustrate: from brilliant red paper cut out a cross about four inches long with bars an inch and a half wide. Place the cross in good light and gaze at it steadily for about ten seconds, then look fixedly at a wall of gray. After a few seconds a cross of greenish tint—the so-called negative after-sensation—will appear. Try it again, this time looking away to a wall of green, yellow, or some other color, or at an irregular surface, or at a corner instead of a flat surface. Try looking at walls at different distances, or in light of different intensities. It will be found in a series of such tests that:

(1) With practice the after-sensations may be seen more clearly.
(2) Expectations may disturb observation.
(3) The conditions surrounding the observation influence the results.

To secure trustworthy facts, it is necessary to isolate the materials to be observed by removing irrelevant objects and distractions, etc., and by controlling other conditions, such as the brightness, color, shape, and distance of the background to which the after-sensation appears to be projected.

When the investigator is interested in discovering relations, causes and effects (as he usually is) as well as merely observing particular facts, it becomes absolutely essential that all of the factors present be controlled. Thus, to ascertain the influence of the vividness of the red cross upon the character of the negative after-sensation, it would be necessary, not only to perform several tests in which crosses possessing different degrees of vividness were presented, but also to have all other conditions—the time of exposure of the cross, the amount of light in the room, the character and distance of the walls, the physical condition of the eyes and body generally, the attentiveness of the subject, etc.—constant. Similarly the influence of any other variable, such as the length of fixating the color-cross, could be ascertained by allowing it to vary from test to test while the other factors remain the same. By continuously investigating in this way, the influences which control certain changes in the duration and character of negative after-sensations could be ascertained.

When the several conditions just described have been fulfilled, the procedure is usually called an experiment,

and the method, experimental. Typically carried out by a trained worker, an experiment then is an observation in which the facts to be observed have been isolated, all other factors have been brought under control, and provisions have been made so that the whole procedure may be repeated by others. An experiment differs from ordinary observation in that it is more carefully planned and executed, is more rigorous, systematic and open to verification by others.

Mechanical Aids to Observation and Permanent Records.—Even under the most carefully controlled conditions, the finest observers frequently secure results that are incomplete and erroneous. Many important events are intrinsically elusive or obscure. Much ingenuity has therefore been employed in the search for mechanical devices designed to supplement or supplant ordinary observation. The astronomer utilizing the telescope, and the physiologist the microscope, are able to make observations more accurate and detailed than could be secured by the unaided eye. Especially sought are instruments which yield a permanent record that may be studied at any time by any person. Instead of the verbal report of an investigator concerning the facial expression of fear in an infant, it is better for scientific purposes to have a photograph record. Better than a report of the movement of the eyes in reading is a graphic record obtained by use of an apparatus invented for that purpose. Instead of estimating the pulse, respiration and glandular changes during excitement, it is better to use mechanical devices which yield tracings or chemical changes that may be preserved. Advances in psychology, as in other sciences, have resulted from the invention of instruments that have made observation more detailed, accurate and extensive.

The Use of Measuring Devices.—Despite all precautions taken and mechanical aids used in observation, a further type of instrument is nearly always useful and frequently essential, namely, an objective quantitative test or measuring device. It has been found—to illustrate—that the passage of time is judged to be more rapid when it is filled with interesting activities than when one has nothing to do but observe its flow. Two intervals, one filled and the other unfilled, which are judged to be equal, would in actual fact be unequal.

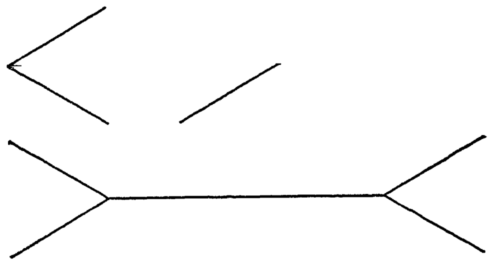


FIG. 1.—THE TWO LINES ARE ACTUALLY EQUAL IN LENGTH.

Here then is an error of observation that would be made by all observers under the most carefully controlled conditions; repetition of the experiment would not disclose the error but, on the contrary, tend to fix it as a fact. By applying an instrument, a watch, which yields an objective measure of the two intervals, the truth is discovered. Above are two lines which nearly every one would judge as unequal, but by applying a foot-rule, their exact lengths, which are equal, will be disclosed. Practice in observing many situations of such types as these will result in improvement, but only when the successes and errors are made apparent by an objective measurement or some other objective device. Even where such gross blunders as these are unlikely, measuring devices are often

essential to yield observations that are sufficiently refined for scientific purposes. Rough estimations of height, as tall, medium, short; of heat as hot, warm, cold, and the like, may satisfy many everyday needs, but for scientific purposes distance often must be measured in thousandths of an inch and heat in thousandths of a degree.

In psychology, as in other sciences, the need of objective measuring devices is acute and great progress in knowledge has followed many inventions already made. Many of the devices are adaptations of instruments used in other sciences: the timing clocks for measuring the speed with which a person may react by speech or finger movement to a sound, electric shock or flash of light; electric mechanisms which measure intensities of changes in glands of the skin, and graphic devices for measuring the frequency and duration of eye movements during reading or following the outline of a circle. Other measuring devices have originated in psychology itself, and constitute some of its outstanding achievements: the development of scales for measuring general intelligence, aptitudes for music and mechanical work, and for measuring achievement in vocational, scholastic and artistic activities. Where measuring devices have not been perfected, as for many complex human traits such as those indicated by such terms as initiative, ambitiousness, excitability, knowledge of their genesis and rôle in daily life remains inexact.

The Use of Statistical Methods.—The early applications of measuring instruments to human beings disclosed at once the fact that individuals differ greatly. To disclose adequately any characteristic of the race as a whole, it is, therefore, necessary to measure not merely one but many representatives, properly selected. The necessity of portraying and easily handling groups of measures led

to the development of statistical methods. Every competent student of psychology must now have some familiarity with, if not a mastery of, such methods. These methods are necessary because one constantly encounters such problems as: How many girls and boys, properly selected, must be measured by an intelligence test before a statement concerning sex differences in general may be advanced? If a hundred boys have been measured, how great is the probable difference between the average of their performance and the average based on a million boys, similarly selected and measured? Statistical methods assist in answering such questions. The application of measuring instruments to human activities has disclosed another fact—the same individual varies appreciably in quality and rate of performance from moment to moment. To secure a truly representative measure of a person, therefore, it may be necessary either to give several tests at intervals or to test continuously for considerable time at one sitting. A half dozen trials in a test of the speed with which a subject can react to a sharp sound by jerking his finger from an electric switch key may be insufficient to portray his average or typical ability; a three-minute test in assembling mechanical contrivances may be insufficient to disclose his aptitude in that kind of mechanical work. By the application of statistical methods, the reliability of a measurement—how adequately it portrays an individual's average or "normal" performance—may be ascertained.

These are but samples of the uses of statistical methods which now form a part of the program for accuracy and precision in the scientific study of human behavior.

Summary.—The scientific method of study embraces a number of features which aim to increase the reliability, fullness and minuteness of observation.

(1) The investigator should be trained in observing the particular items of interest.

(2) He should learn to avoid the misleading influences of expectation and prejudice, should develop a "scientific" or open-minded attitude toward his problems.

(3) He should arrange carefully the setting for observation, isolate the pertinent material and eliminate or control other factors.

(4) He should so describe the conditions that he and others may repeat the whole investigation.

(5) Whenever possible, he should supplement his observations by the use of mechanical devices, especially those which yield a permanent record of the facts.

(6) Whenever possible, he should present the observed data in quantitative terms, in the form of a measurement.

(7) These should be analyzed by statistical methods in order that the reliability, in so far as the data depend on the extensity of the observations, may be ascertained.

Generalizing from the Facts Observed.

Science Attempts to Explain Its Observed Facts.—Thus far, the discussion has been confined mainly to the errors of observation and the devices utilized to avoid or remove them. The accumulation of trustworthy observations or particular facts is but one phase of the work of science. Equally important and equally difficult is the interpretation of facts, the development of general laws and principles. When Benjamin Franklin flew his kite in a thunder-storm, he observed a phenomenon, an electric spark jumping from the cord. Verified on other occasions, it was recognized as a fact. When Franklin stated as a result of his observations that lightning was merely a huge electric spark, he had gone beyond the observable facts. He had developed an hypothesis which was borne out by later investigations and finally accepted as a general principle, a law or general truth.

An hypothesis is any conception by means of which the mind goes beyond the facts and seeks to establish relations between data that have been observed. It is a conjecture, a guess, a provisional explanation; it is an interpretation or enlargement of what is observed. The development of hypotheses is one of the important features of scientific work. The ability to generalize or theorize has been the outstanding characteristic of most eminent men of science. Conjecturing, guessing, theorizing, is not confined to any one period of an investigation; it is usually incessantly active, preceding, accompanying, following and guiding all experimentation.

Differences in interpretation are usual; everywhere are encountered rival hypotheses which must eventually be evaluated not only on the basis of further observations but also in the light of certain principles of guidance in interpretation. Just as there are checks, controls and accepted rules to guide observation, so there are devices for avoiding errors and reaching the most effective conclusions in thinking about facts collected. It is quite as difficult to think validly as to observe accurately. The scientific method, consequently, comprises a series of rules, all of the rules of logic and in addition certain others that are designed to guide the construction of hypotheses.

Science Favors the Hypothesis Which Has the Widest Application.—Other things being equal, science accepts the hypothesis which explains the most, which has the widest application. Psychology, for example, seeks a single formula by means of which to explain the mechanics of all behavior, both of body and mind, in normal and abnormal individuals, in animals as well as man. It favors one type of explanation for learning of all sorts, swimming, singing, control of anger,

memorizing, solving geometry problems, rather than one set of hypotheses for acquiring muscular skills, another for modifying emotions, and another for accumulating information. Rival hypotheses are being constantly tested by *application* to new particular facts as they appear. That hypothesis which explains, most adequately and widely, the known facts is the one most acceptable to science.

Science Favors the Simplest Explanation; the Law of Parsimony.—Of several rival hypotheses, equally good in other respects, science favors the one which affords the simplest explanation. In one form or another, this rule, which is known as the Law of Parsimony, has been accepted by all sciences. What shall be meant by simplicity must be determined by each science for itself. In psychology, the Law of Parsimony has been, for many purposes, quite satisfactorily stated in what is known as Lloyd Morgan's Canon, which is here quoted from his "Introduction to Comparative Psychology" (1894): "In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty (mental process) if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale." To illustrate Lloyd Morgan's Canon, let us suppose that our dog, caught in the forbidden pantry, cowers and whines piteously. What are the possible explanations of such conduct? Since the dog has been carefully trained to keep away from the pantry, and is an intelligent and well meaning animal, he is suffering pangs of conscience. One can discern remorse and penitence in his tones; he simply regrets the sinfulness of his ways. Another explanation might be this: when the master happens upon the dog, the animal consciously remembers—has in fact a vivid mental picture—of what happened when he was last sur-

prised in the pantry. On the basis of this memory revival, it was easy to reason what would probably be shortly forthcoming, hence the cowering and whining. A third explanation would be: the dog has for good reasons cowered and whined when previously caught in the pantry. Now, being confronted by the man-pantry situation, he reacts by cowering and whining, a direct motor reaction unattended by "conscience," "reason," "conscious memory," or any other "higher" mental process. The psychologist would probably accept the last explanation (or one somewhat like it) because it is simplest in the sense of being lowest in the scale of psychological explanation.

Psychology more than most sciences must be rigid in applying the Law of Parsimony, because fanciful and mystical explanations are supplied with such readiness. The prevalence of beliefs in magic, clairvoyance, telepathy, mind reading, mystic inspirations, premonitions, intuitions, and mind cures is illustrative of the readiness with which the supernatural rather than the simplest of psychological explanations are accepted. A New England girl, Beulah Miller, found herself possessed of a mysterious ability to divine many of her mother's thoughts; for example, she could tell whether her mother was thinking about the clock, the carpet, or the window, about the number 6 or 10. The girl was entirely ignorant of the means by which she accomplished these feats. While thought transference, independent of the channels of the ordinary senses, is suggested by such a performance, the psychologist must search for simpler explanations. In this case it was found after careful investigation that the girl, without knowing it herself, was getting her cues from slight eye, lip, or bodily movements of the mother who was not aware of having made them.

The Use of Laws in Prediction.—Guided by rules, samples of which have been suggested, hypotheses are formulated, tried out to be discarded or to be advanced to the stage of a recognized theory, and if fully verified, to be finally accepted as a law, principle or general truth. Laws or principles are what sciences eagerly seek. The prime value of the general law is that it provides the means of making predictions, explaining all manner of particular facts, and foretelling consequences. The astronomer utilizing the laws concerning the movement of planets can predict the exact moment at which the sun will rise each day for many years in the future. The physician observing certain symptoms, pulse, temperature, and the locus of pain, by virtue of known principles predicts, with more or less accuracy, the course of a disease and arranges the treatment accordingly. The psychologist, utilizing the principles of mental growth, predicts, at least roughly, from the results of an examination made at age seven, the degree of mentality that a particular pupil will possess at fifteen, and as such predictions become more precise, the educational and vocational treatment of children may be more adequately selected and controlled to suit the ability and needs of the particular individual. In so far as we are able to predict the future from the present, we may be able to meet the future more adequately. Prediction is an ultimate aim of scientific endeavor.

Summary.—The scientific method is the result of extensive study of the difficulties and pitfalls in observation and the defects and deficiencies in generalizing from observed facts. It comprises improved methods both of observing and generalizing from data observed. Scientific knowledge differs from "popular" ideas mainly in these respects: it is

(1) More definite and precise.
(2) More accurate and valid
(3) Better analyzed and organized.
(4) More universal in application.

The essence of science is its method. What distinguishes one science from another is the subject matter studied. Psychology is a science so long as it abides by the rules and regulations of the scientific game. Psychology, then, is the application of the methods of science to the study of certain data. What the data are and how they yield to or resist scientific attack should receive brief consideration.

The Subject Matter and Special Methods of Psychology

Sample Problems.—Conceived broadly, psychology seeks to discover the general laws which explain the behavior of living organisms. It attempts to identify, describe and classify the several types of activity of which the animal, human or other, is capable. Psychology endeavors to ascertain what bodily organs are engaged in locomotion, in vocalization, in approaching and avoiding objects, in angry and affectionate behavior, in seeking escape from dangerous or difficult surroundings, and, in the case of human beings, at least, in reading, recalling facts, perceiving distance, or reasoning out the solution of a problem. It seeks to determine which of the many forms of activity or abilities appear without learning; which like the breathing of a newly-born infant are the results of inner growth rather than training. Psychology also seeks to determine the principles which explain the process of learning in the case of abilities which are acquired or modified by means of experience. It seeks to discover whether the principles of economy in

learning are the same or different in the acquisition of motor (i.e., muscular) skills, knowledge about objects and events, emotional control, appreciations, and other types of learning. Psychology attempts to discover the amount and nature of differences between species—cats, monkeys and men—and the differences among members of the same species in mental and motor abilities, native and acquired, in methods of adjustment to their environment, in capacities to learn, in fact, in all phases of their conduct.

Study of Behavior by "Objective" Methods.—In all of these endeavors, psychology seeks to discover and utilize the means of study which most closely approximate the thoroughly scientific method. When the subject of investigation is another person or animal whose activities, such as movements of hand or limb, facial expressions, or vocalizations, may be observed directly or by the aid of recording or measuring devices, psychology may utilize precisely the methods of other natural sciences—physics, chemistry or botany. The behavior of a man or animal may be studied quite as directly and scientifically as the bending of a steel rod under weight, the activities in a mixture of chemicals or the movements of the petals of a flower shifted from darkness to light. Just as in other sciences, all of the devices and precautions, which form the essence of the scientific method, may be utilized in the study of human and animal behavior. When the investigator restricts himself to observations of movements of limbs, eyes or facial muscles, to observations or records of vocal expressions, glandular activities or secretions which may be directly observed, recorded by an instrument or analyzed chemically; when, in sum, the investigator observes features of the behavior of an animal or man which other investigators could also

study—were they present—the method is termed *objective*.

Study of Consciousness by the Method of Introspection.—We must now raise the question whether all the facts which may be useful in describing and explaining the behavior of man or animals can be observed in this objective way; whether all the facts may be observed by several investigators. It is at once apparent that there are many activities or experiences in human life, at least, that are limited entirely to one person. In this category fall the facts of consciousness, those conscious experiences that are exclusively individual or subjective. As I now write these words, I become aware of a slight pain from a bruise on my foot, of the initial pangs of hunger, of the desire to finish this section of the discussion before lunch. I am aware of strivings to make this discussion clear, and as I attempt to secure relevant facts, I recall vague visual impressions of persons who have written on the same subject. No one else can share these observations; no one can verify them. What is more, no one can record them by graphic or photographic devices, by chemical analysis or in any other way. They are open only to my observation; they are purely subjective. There are, then, some facts in human experience that cannot be studied in exactly the way required to satisfy completely the demands of the scientific method. These are the facts of personal conscious experience—sensations, such as toothache, muscular strains or coldness, feelings of pleasantness or unpleasantness, recalled images and ideas, impulses to run or weep, desires, motives, and other conscious data. The observation of such personal experiences is usually termed *subjective* or *introspective;* the method is termed the *introspective* method to distinguish it from the objective type of observation.

There is little doubt that a valid description, classification and explanation of such conscious experiences would be of great value to psychology in its efforts to explain human behavior in general. Everyone knows as the result of ordinary experiences that bodily sensations, feelings, emotions, images, memories, and impulses are associated with and conditioned by overt (that is, open-to-view) conduct. The better we know the nature of conscious life the more fully we may be able to understand and predict all behavior. Indeed, the common sense view is that the task of isolating the different phases of conscious experiences, of relating them to bodily organs, of discovering the relation of one to others and the functions of each in the behavior of the organism, as a whole, lies rather exclusively within the province of psychology. This view is entirely correct. Psychology must accept the responsibility of doing all that may be done to describe and explain the facts of mental life in order that they may be related to the facts of behavior as a whole.

A Typical Problem for Introspection.—The difficulties of obtaining reliable observations of conscious experience may be appreciated better after attempting a fairly complex type of introspective study. You may try an experiment, now classic, first described by the eminent scientist, Sir Francis Galton. Seat yourself comfortably and try to recall as vividly as you can the morning's breakfast table. Can you see, in your mind's eye, the table, dishes, faces, food, and other details? Are these visual images dim or clear? Are they as bright as the actual scene? Can you really imagine the colors of the china, of the toast, eggs, coffee, etc., quite distinctly? Can you imagine the whole scene at once? For example, can you imagine all four walls of the room at once, or only the area that you could

see from the particular position in the room? Where do the images seem to be situated? Within the head, within the eyeball, just in front of the eyes, or at a place corresponding to the real situation of the room? Can you retain the image steadily? With or without effort? Can you project it to the wall?

Methods for Increasing Reliability of Introspective Study.—Such observations are difficult because the conscious data are usually complex, unstable and shifting. It is difficult to concentrate fully on the images, to the exclusion of everything else seen, heard, recalled or felt, and at the same time, introspectively study the characteristics of the images. Conscious experiences of this and many other sorts are intrinsically difficult to observe. To bring introspective study as nearly as possible to the scientific ideal, the usual precautions are taken. The investigator should obtain favorable conditions for study by working when and where free of distractions. He should, moreover, secure abundant training in setting himself to the particular task and of holding rigidly to it. In this type of observation as in others, increased skill may be achieved through rigorous training. Expertness is possible here and in other fields. The investigator should repeat an observation and record the results, which then may be given statistical treatment. Since no one's mental images can be objectified or made accessible to other observers, psychology must rely upon the carefulness, expertness and trustworthiness of the individual observer.

Some there are in the ranks of psychology who distrust the validity of the introspective method because of the limitations which have been mentioned. The majority approve its use while recognizing the need of care and caution. Those who favor it contend that if similar

experiences are reported by different people independently, or if the same observer, known to be well trained, careful and trustworthy, has the same experience repeatedly, the observation should be considered reliable quite as other types of experimental evidence. In Galton's experiment, for example, many trustworthy individuals repeatedly found that their imagery of the breakfast table was "brilliant, distinct, never blotchy," others found it "fairly clear, brightness at least from one-half to two-thirds of the original," while others found their imagery to be "zero—no visual memories—recollect but do not see the scene." These reports are at once of useful reliability and in rough quantitative terms. The investigator may arrange a "scale" in which the highest degree of vividness is connected with the lowest by a number of steps or units which are roughly equal.

Introspective study is admittedly difficult, and unusual care must be exercised in utilizing the results of its use. It is the only mode of approach to some important problems and psychology must accept the task of demonstrating whether the method in the hands of experts yields evidence sufficiently reliable for scientific purposes.

TYPES OF INDIVIDUALS STUDIED.

The Study of Normal Human Adults.—In general psychology, interest tends to center in the normal human adult. By the "normal" adult is meant a person, 18 or more years old, without conspicuous defects or deficiencies. Studies of consciousness have been confined almost entirely to adults, indeed, mainly to experienced psychologists and college students at various stages of practice in introspective study. As subjects of the more refined methods of objective study embracing the features of the experimental method, college students and

instructors have also been chiefly utilized. Since these are rather select groups in some respects,—for example, in intelligence,—there is always some danger that the obtained results will be not typical of all mankind. As far as possible, these results are checked up by observations of other people, dull, average and bright, in the varied activities of everyday life as well as by more precise investigation in the laboratory. In addition, checks and controls are often obtained from studies of abnormal adults and of children and animals, both normal and abnormal.

The Study of Children.—Children from birth to maturity are studied not only to provide an understanding of their behavior, but also to make more intelligible the behavior of adults. Adult behavior evolves from, and is influenced by, the growth and experiences of earlier life. Tracing from year to year the development of bodily organs and their functions, intelligence, skills, emotional tendencies and moral habits by consecutive observations and measurements is an important phase of psychological study. This type of investigation is often called the *genetic method.*

For some purposes, children are admirable subjects, for others, they are quite unsuitable. The introspective reports during early childhood are not highly reliable and the study of consciousness by subjective methods is untrustworthy. For objective study children's behavior offers certain advantages—it is often less complex and less distorted by unknown past experiences than that of adults. Since their likes and dislikes, fears and angers, impulses to strike or eat, their motives in general are less frequently and skillfully concealed, their observable behavior is a better index of the full adjustment of the organism. The processes of learning to walk, talk, handle

implements, read or solve problems, may be studied profitably since they form slowly and may be traced from the beginning. The development of instrumental aids to observation and measuring devices for use with children has been specially extensive and successful. Indeed, so far as quantitative study is concerned the equipment for dealing with children is now superior to that for investigation upon adults.

The Study of Animals.—Since there are reasons for believing that human behavior, like the human body, has evolved from and is therefore in many respects similar to, even if more complex than, animal behavior the study of animals has been prosecuted with results of value in interpreting human conduct. For the fruitfulness of such study there are four important reasons. First, the behavior of animals is usually more simple. When animals are encouraged to learn, the slowness and obviousness of their progress makes detailed observation possible. Here the processes of learning in its simplest terms may be detected yielding principles that may be applied to explain human habit formation. Indeed, some of the important generalizations concerning human learning have originated in just this way. Another advantage of animal study, in some instances, lies in the brevity of the span of life. All that an average rat, for example, does and learns from birth to senility may be observed in about 30 months, the normal life of some species of this animal. The study of animals affords another important advantage; their activities, more than those of human subjects, may be controlled more completely and for longer periods, even for a lifetime. An investigator may not refuse the child its privilege of attempting to walk until months past the usual time in order to ascertain to what degree walking is a result of inner growth as con-

trasted with practice, nor may he isolate the child from human intercourse to discover what type of vocalization, if any, would result, but birds may be comfortably housed so as to prevent practice in flying or in imitating the songs of other birds until a time well beyond the time when these activities normally appear. In this way important facts concerning the inherited or instinctive equipment of animals may be learned. Another advantage in the use of animals as subjects is the possibility of observing as a result of operation the loss or distortion of activities which follows the removal of organs. Thus by extirpation of parts of the brain of animals much has been learned of the function of that complex organ.

Observation of animals must be wholly objective, of course; consciousness cannot be directly studied. At best, it may be indirectly inferred from the animal's behavior, but such practice is too uncertain to yield much of value for interpreting the human mind.

The Study of Abnormal Individuals.—Among animals, children and adults, individuals that deviate widely from the average either by inherited aptitude or deficiency or by acquired ability or defect prove to be fruitful subjects for study not only because it is important to understand them but also because they often disclose in clear relief the normal rôle of organs and functions. Studies of the blind and deaf and of patients whose brains or spinal cords have been partly destroyed by accident or disease have contributed greatly to the knowledge of functions of these organs. In feeble-minded children, criminal adults, the emotionally or nervously unstable, the insane, the usual human functions are often found either in such limited or exaggerated degree that they are more readily isolated from other functions than in the normal. Similarly profitable studies have been made of the extremely

bright child, the lightning-calculator, the champion typist, the master musician, mechanic or executive as well as of instances of exceptional memory, imagery and sensory acuteness.

Varieties of Psychology.

The field of psychology is so broad and the methods and interests of its workers are so numerous that it is customary for the sake of convenience to indicate subdivisions or varieties. It is sometimes divided broadly, according to predominant method of attack, into

(1) The study of consciousness which is usually called Introspective Psychology.

(2) The study of behavior, which is called either Objective Psychology or Behavioristic Psychology.

Other divisions are often made according to the type of subjects studied. Thus arise such varieties as Animal Psychology, Child Psychology, Human Adult Psychology, Abnormal Psychology. Certain limited phases of the general subject which may not be confined to either of the general methods of attack or to any class of individuals are often given special names. Thus we have Physiological Psychology, in which the main items of interest are the form and functions of the bodily organs including the nervous system and the relation of these to mental and bodily activities; Dynamic Psychology, in which the springs of action, motives, drives, urges, wants, as they are variously called, are especially stressed; Social Psychology, in which the activity of the individual—animal, child or adult, normal or abnormal—in his relations to other individuals of the same species is studied; Differential Psychology, in which the amount, kind and

significance of individual differences are the main objects of inquiry. The varieties enumerated do not exhaust the list but they indicate the fact that there are many fields for specialization of interests with a great deal of overlapping among many of the branches.

Applied Psychology.—Applied Psychology is sometimes stated to be, not a branch or variety of the general science, but an art of putting psychological facts and principles to work for practical ends. The fields to which applications may thus be made are almost innumerable; to industrial work, to business in general, or to advertising, buying, selling, selecting employes; to the practice of medicine, law, and education; to religious, social or philanthropic work, etc. To apply psychology to these and other practical activities, however, rarely fails to assist the general science and often becomes an important part of it, in two ways. The deficiencies or merits of hypotheses are disclosed by applying them to new situations. This is the way in which valid laws and principles are built up; and this is precisely what Applied Psychology does. Thus we find that the use of tests of mental imagery and the wider use of tests of general intelligence in school, business and industry by competent hands has added greatly to our understanding of certain aspects of human nature. Again, the workers in Applied Psychology rarely find principles sufficient to solve all their particular problems. These problems are then often attacked by methods like those utilized in the general science. The result may be a body of new experimental data by which the science itself is enriched.

General Psychology.—From the many fields of study, with a diversity of particular methods, subjects and interests, have been gathered a body of facts, hypotheses and principles which constitute General Psychology.

General Psychology is a group of facts and principles which purport to explain the behavior of living organisms in general. The term behavior is here used broadly to include the characteristic features of such reactions as man and other animals may make in adjusting to their surroundings, in getting along in their world.

This book treats of certain phases of General Psychology with particular emphasis upon the explanation of human behavior. It is called Elementary Psychology since it is not an exhaustive treatment; it omits especially the more highly technical phases of the subject.

QUESTIONS AND EXERCISES

Following each chapter is a group of exercises and questions designed to assist students in clarifying and testing their mastery of the text and to stimulate application of the facts to other situations. Free discussions of the exercises by students in small groups will be specially fruitful. Among the questions following the first few chapters are examples of several of the new types of objective tests now profitably used in many places. They afford rapid and comprehensive tests of the important points in the chapter. Tests of these types are not continued through the book inasmuch as to make up such exercises is as valuable as to solve them. It is suggested that each member of a study group make up a list of such exercises for each chapter and give them to the other members. Such a practice will provide most effective study and review. Samples of several types of exercises follow.

A. *The True-False Test.* Mark each statement as true or false.

1. Psychology utilizes but one scientific method, namely, the method of introspection.
2. Experiments show that the average witness in court may be trusted to report accurately what he observed provided he was calm during the observation and honest in intent.
3. Psychology, like many other sciences, seeks quantitative data.
4. The difference between an hypothesis and a theory is a difference in the degree to which an explanation has been verified.
5. The text implies that when one learns to observe better one class

of data one may be able to observe little, if any better, other types of data.

6. General psychology is concerned with the behavior of animals as well as of man.
7. Psychology finds it necessary to exclude entirely from consideration the abnormal mind in order to avoid erroneous ideas concerning normal behavior.

B. *The Multiple Choice Tests.* Mark the one best answer to each question with an (x).

1. Psychology is probably mainly concerned with
   ( ) Problems of the immortality of the soul.
   ( ) Telepathy and mind reading.
   ( ) Ordinary thinking, feeling and conduct.
   ( ) Ordinary digestion, breathing and heart action.
2. Psychology differs from popular thinking mainly in
   ( ) The kind of problems it attempts to solve.
   ( ) The lack of practical value in its interests.
   ( ) The irreligious attitude which it takes toward life.
   ( ) The precision and care in the methods of study used.
3. The best definition of general psychology is
   ( ) Study of general behavior.
   ( ) Study of consciousness.
   ( ) Study of conscious behavior.
   ( ) Study of human nature.
4. The introspective method is less satisfactory than objective methods because
   ( ) Introspective observation is more difficult intrinsically than objective observation.
   ( ) It is more difficult to train people to introspect.
   ( ) It is impossible for two people to observe the same facts in introspective study.
   ( ) Introspective study requires a peculiar self-centered type of observer that is rarely reliable.

C. *Completion Tests.* In the blank spaces in the following sentences, write words that make a complete and accurate statement.

1. In reports of scenes observed even professional men made from .... per cent to .... per cent incorrect statements.

2. We can estimate causes and .... only when all .... have been .... or taken into account.
3. Whenever possible, the investigator supplements or .... ordinary observation by the use of .... such as a .... or a ....

D. *Brief Response Tests.* Answer each in a word or phrase.

1. It was stated that in psychology, as in other sciences, the hypothesis is generally accepted which is simplest, which explains the most and is most in harmony with facts in related fields. What is this principle called?
2. When we have a trained observer, careful arrangement of conditions for observation, careful control of all influences, and the recording of details during the study thus making provision for repetition, what term may be applied to the study?
3. What is the main function of the general law or principle in science?

E. *The Outline Test.*

1. Give seven methods or devices utilized in psychology for the purpose of making observation more effective.
2. Give three criteria by means of which hypotheses are tested.
3. State and illustrate the two main types of subject matter in psychology.
4. State the main reasons for studying each of four kinds of individuals in psychology.
5. Name several types or branches of psychology. How are they related to General Psychology?

F. *Questions and Exercises for Discussion.*

1. Criticise the following opinions from the point of view of the methods and evidence. Suggest how the opinions might be tested by scientific methods.
   a. A man states that women are less reliable in emergencies than men because he has observed frequent panics in his wife during critical situations while driving an automobile.
   b. A man asserts that alcohol has a stimulating effect on the mind because whenever he has been drinking a little he observes how witty he becomes.
   c. A man asserts his belief in mental telepathy because he dreamed one night during the war that his son was injured in battle and later found that such had been the case.

d. Tobacco can injure no one as proved by the fact that several very aged men are habitual smokers.
e. Animals have conscious memory as anyone who owns a dog recognizes.

2. What is the distinction between introspection and reasoning or philosophizing?
3. Which of the following experiments would necessarily be studied by introspective methods: (a) the determination of whether anger increases one's mental acuity; (b) whether anger is pleasant or unpleasant; (c) whether a dog is angry or not; (d) whether a dog can see colors; (e) whether a man can see colors; (f) whether the color preferences of women are the same as those of men; (g) whether one can really imagine the taste of sweet; (h) whether alcohol affects one's vision.
4. Try the negative after-sensation experiment described in the chapter several times during the course of a week to ascertain whether any perceptible improvement in this type of observation results. Try the experiment with children of different ages. Do you think they could become reliable observers in this field? If so, at about what age?
5. How would the facts concerning the unreliability of observation probably apply to your recollection of the materials in this chapter after a first reading? Do you suppose it possible that some of the material might be quite incorrectly recalled? How would you arrange to test the reliability of your observation and memory for such facts experimentally? How determine the number of readings necessary for reasonably full and accurate recall?
6. What is the distinction between a civil law and a scientific law?
7. What are the differences between a jury trial and a scientific test of facts? Does modern legal practice take into account in any way the methods that science finds useful?
8. At this point, spend a few minutes running through the table of contents—as a substitute for a precise definition of psychology, which the writer has not attempted in this chapter—and then scrutinize each of the following definitions to see which ones, if any, most adequately embrace the topics to be taken up in this book. Which ones seem too narrow or too broad in scope.
   a. "Psychology is the science of mental life, both of its phenomena and of their conditions." (William James)
   b. "The business of psychology is to furnish a systematic and

coherent account of the flow of the psychical process in its various forms, phases, and stages, and of the conditions on which it depends." (G. F. Stout)

c. "Psychology is that division of natural science which takes human activity and conduct as its subject matter." (J. B. Watson)

d. "Psychology is the science which deals with the mutual interrelations between an organism and its environment." (H. C. Warren)

e. "Psychology, in a word, is the science of the conscious and near conscious activities of living individuals." (R. S. Woodworth)

f. "Psychology seeks to explain the facts of intellect, character and personal life." (E. L. Thorndike)

GENERAL REFERENCES

For fuller treatments of the general methods of science, see R. W. Sellars, *The Essentials of Logic,* Boston: Houghton Mifflin, 1917, especially pp. 173-239, W. C. Cooley, *The Principles of Science,* New York: Holt, 1912, or *An Introduction to Reflective Thinking,* by Columbia Associates in Philosophy, Boston: Houghton Mifflin. 1923.

For a more thorough discussion of the introspective method and a body of facts obtained by its use, see E. B. Titchener, *A Textbook of Psychology,* New York: Macmillan, 1919; for a psychology in which objective study is utilized nearly exclusively see J. B. Watson, *Psychology from the Standpoint of a Behaviorist;* Philadelphia: Lippincott, 1919; or S. Smith and E. R. Guthrie, *General Psychology in Terms of Behavior,* Philadelphia: Appleton, 1919. Nearly all other recent books discuss and utilize both methods.

Probably the most useful single book for supplementary reading is *Readings in General Psychology,* by E. S. Robinson and F. Richardson-Robinson, Chicago: University Press, 1923, a compilation of brief passages from many writers on topics treated in this text.

The following books or syllabi contain questions and exercises on many of the topics in this book:

W. J. Gifford, *Introduction to Psychology; A Syllabus,* Harrisburg, Va.: Garrison Press, 1922; A. J. Snow, *Problems in Psychology,* New York: Henry Holt, 1923; and J. P. Wynne, *Guide to Educational and General Psychology,* New York: Fordham Publishing Company, 1924.

CHAPTER II

THE RÔLE OF THE RECEIVING MECHANISM IN BEHAVIOR EXPLAINED AS REACTIONS

As we observed in the preceding chapter, each science attempts to develop broad principles by means of which its particular facts may be explained. Until undisputably established, such general explanations are properly termed hypotheses or "working hypotheses." The good hypothesis must fulfill certain requirements. It must faithfully explain the particular facts on which it is based; it must be wide in its application, explaining all the facts within its field; it must afford the most simple and workable explanation and it is furthermore desirable that it should square up with facts and principles established in other fields, such as physiology or physics. Before undertaking the detailed problems of psychology it is desirable, therefore, to present in brief a working hypothesis which is fundamental in all later explanations. This will give the main point of view that will be elaborated and substantiated throughout the book.

The Reaction Hypothesis

Briefly, the hypothesis is as follows: all forms of human behavior, whether muscular activities, such as grasping, walking and speaking; glandular activities, such as the secretion of tears, saliva and bile; or mental activities, such as seeing, hearing, becoming afraid or angry, recollecting or imagining, are *reactions* to definite stimuli. This may be called the *reaction hypothesis*.

Muscular Movements Are Reactions.—If a sharp pinpoint is applied to an earthworm, a dog, an infant or an unsuspecting adult, the usual result is a sudden and pronounced movement. The essential features of this bit of behavior are, the stimulus, the reaction or response and some sort of connection between the two. The stimulus here is an activity or force which manifestly has some effect upon the organism; which arouses the organism—at least some part of it—to activity.

The stimulus to produce effectively a reaction must impinge on some sensitive portion of the body. The pin, in this case, was brought to bear upon one or more tiny sense organs which were located in or under the skin. Since the movements made in response to the stimulus were not all located immediately at the point of stimulation it is apparent that the effects of the stimulus on the sense organ were conducted over various distances to the muscles. Examination, indeed, would disclose between sense organs and muscles an elaborate system of connections, the cells and fibres of the nervous system. It is a nerve impulse initiated at the sense organ by the stimulus and conducted through a system of nerve fibres (first to centers in the spinal cord or brain and thence back) which touches off the reaction in the muscles. The *reaction,* in this case a movement, is an activity produced by the release or transformation of energy. A muscular movement or "motor response" is due to the sudden release of forms of energy stored in the muscle.

A reaction, as the term is here used, means more than the mere transmission of energy from one object to another as when a moving billiard ball, striking another, throws the latter into action. The amount of energy released or transformed may be very much greater than the amount transmitted to the organism by the stimulus.

A tiny prick occasioned by a very small amount of force may cause a reaction in which a relatively huge amount of energy is consumed, or more accurately, transformed. The organism contains at all times stored in various reacting mechanisms large amounts of energy which when released by appropriate stimulation occasion the body's activity.

That all motor activities are to be explained in terms of the stimulus-reaction formula is generally agreed since the mechanisms involved, the sensory or receiving mechanisms, the connection mechanisms and the reacting mechanisms, in this case the muscles, are fairly well understood and their combined activity may be observed with relative ease. In everyday experience we observe that a tickle causes a quiver or a sneeze; a pinch causes a jerk, a strong light causes a wink or the narrowing of the pupil of the eye. In the laboratory such simple reactions may be more precisely demonstrated, and in many cases the sense organs, nerves and muscles involved may be identified. The more complex motor activities such as talking, grasping an object, balancing on one foot, stopping a "grounder," playing a violin, although immensely more complicated both on the side of the stimulus and the response, nevertheless are of the same character as the more simple acts.

Glandular Activities Are Reactions.—If a strong light or a cinder strikes the eye the muscles of the lid react causing a wink; the eye may also be promptly moistened by a flow of tears. The tears, like movements, are the results of a reaction; the reacting mechanism in this case being a gland—the lachrymal gland. In a similar way heat will cause the sweat glands to react, a taste of sweet the salivary, and certain substances in the stomach, the digestive glands. In the simplest instances, then, gland-

ular activities are brought forth by stimuli which affect sense organs within the body or on its surface. While muscles and glands may differ greatly in structure and while movements and chemical secretions are very different sorts of products both are similarly produced in the sense that they are the results of reactions of bodily mechanisms activated in an orderly way by stimuli.

Conscious Experiences Are Reactions.—When the human subject is stimulated by a pin prick, a ray of light or a sweet substance characteristic muscular and glandular reactions occur and the subject becomes conscious of the pain, the light or the sweet taste. Since these sensations are purely personal experiences not apparent to other observers they are often conceived as rather mysterious activities differing in kind and control from movements and glandular secretions. It appears, however, that they followed upon and were activated by the stimulation of sense organs. They seem to appear as surely and uniformly and to be as law-abiding as the others. In these instances, at least, they may intelligibly be conceived as reactions. More complex conscious experiences similarly are reactions; that is, they are not spontaneously brought into existence but aroused by definite causes. When pricked by a pin the subject is first aware of the pain; that is, he experiences a sensation but at once he may realize that the pain was caused by a pin—he perceives the pin. The event, furthermore, may arouse some resentment or anger, an emotional response; it may lead to the recollection of the circumstances that led to the unfortunate location of the pin, to imagination of serious consequences which may result from even so slight an accident, to reflection or reasoning as to the means of forestalling such results. Thus to a simple stimulus conscious reactions of all sorts, simple and

complex, may be made. They do not appear without some adequate cause; they are, like movements and secretions, the result of the activities of mechanisms within the body.

On first encountering the reaction hypothesis as thus briefly sketched students are likely to raise the objection that the concept is altogether too mechanical; it suggests human behavior that is too completely fixed, inflexible, invariable; too little influenced by varying conditions of attention, mood, desire, and purpose. Fit descriptions these—it may be suggested—for gasoline motors or even for plants and simple animals but not for man whose behavior no one can predict. Now these objections reveal the need of giving further emphasis to the number and complexity of the stimuli which are operating and together determine the reactions at any moment. The fact seems to be that human behavior is not inexplicable and irreducible to law and order, it is merely exceedingly complex.

Typical Human Reactions Are Complex.—Since human behavior is typically complex both when observed from the point of view of the reaction and of the stimulus the need of discovering the elementary principles involved becomes acute. A suitable problem for psychology—to illustrate—is the child's reading or his learning to read. Delicate eye and head movements as he follows the line may be observed; muscular reactions that are quite difficult to acquire. Genuine reading, of course, involves conscious reactions. The child must recognize the words, which also takes time and effort to learn. More than recognition, genuine reading includes comprehension of the ideas and at its best reflection or thought beyond mere comprehension. Nor is this all. The child now laughs with glee, now trembles with excitement or, if it

is a good ghost story, shrinks and pales with fear. Examination of his inner functions under these circumstances will disclose many unusual muscular and glandular activities, contractions, palpitations, inner secretions, flushes and pallors. All of these activities—holding the head, moving the eyes, recognizing the word, comprehension, thinking and reacting inwardly—go on simultaneously and they may be learned together as responses to printed words. Were we forced to utilize one set of explanations for learning to hold the head and move the eyes, another set for perception, another for thinking, and another for properly controlling emotional reactions we would fall far short of that comprehensiveness and simplicity of explanation for which science diligently seeks.

The Stimuli Are Typically Complex.—Human reactions are complex and they are typically brought about by combinations of stimuli equally complex. The boy reading his book or the man walking along the street is not responding to one stimulus only although some one element of the situation may be predominant. Many other stimuli such as objects and events seen "out of the corner of the eye," cries, honks and rumbles, odors, good or bad, heat and cold, are effective at the same time. Compare the effects of the ghost story on a boy surrounded by people at midday and a boy by himself at night! Often equally influential are stimuli which result from immediate or past activities in his own body, his present muscular and glandular activities, his present ideas, emotions, and purposes and such general conditions as those of fatigue, irritability, hunger, hurry, or melancholy. To explain fully what the person does or to foretell what reactions will be made next it is necessary to take into account all of the stimuli, inner and outer.

Because of its complexity the explanation of human

behavior as it appears in daily life must be approached gradually. We must begin with a survey of the mechanisms involved, illustrating some of the simple reactions and advancing gradually to the complex. We must describe in some detail the form and functions of the receiving, the connecting and the reacting mechanisms The remainder of the chapter will be devoted to the first of these, the receiving mechanisms.

The Physical Basis of the Stimulus-Response Unit.—First among the organs is the *receiving apparatus,* sometimes called the *sensory apparatus;* most commonly the *sense organ.* The sense organ always contains one or more *receptors* which are highly sensitive to certain kinds of stimuli. The function of the receptor is to initiate a nerve impulse. Each receptor is in contact with the endings of a nerve. The impulse, resulting from the stimulation of the receptor, is conducted by the nerve to switching stations in the spinal cord or brain. After more or less switching about, the nerve impulse finally is conducted by other nerves to muscles or other mechanisms where the reactions occur. The order of events then is: (1) the stimulus affects in the sense organ the receptors which (2) initiate a nerve impulse which (3) is conducted through the nervous system and (4) finally issues into the reacting mechanisms. The whole system is usually thought of as a unit, a *reaction unit* or a *stimulus-response unit.* A very simple reaction unit is shown in Figure 2.

Form and Functions of the Sense Organs.

Sense Organs in General.—Sense organs vary greatly in complexity. The eye and ear are most elaborate; the organs for pressure and pain are the simplest. The differ-

ences in complexity are due mainly to accessory structures which are not sensitive to the stimulus. Differences in the receptors, the sensitive cells, themselves are too minute to appear to the unaided eye. The receptors are absolutely essential to the initiation of the nerve impulses; the accessory apparatus such as the external shell of the ear is usually of service but not always indispensa-

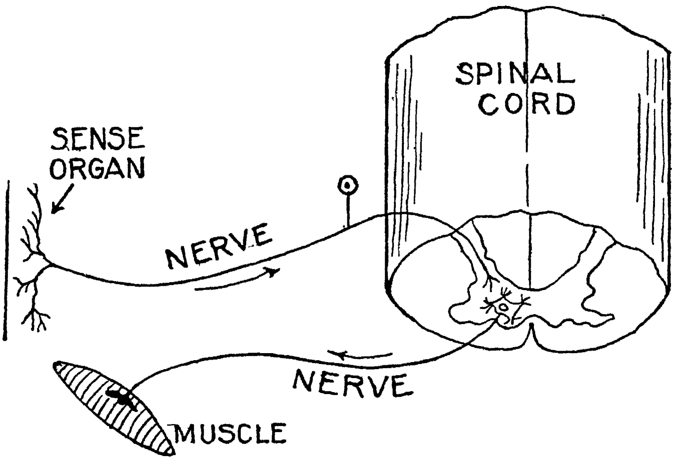


FIG. 2.—A SIMPLE REACTION UNIT, OR SITUATION → RESPONSE UNIT, CONSISTING OF THE RECEIVING MECHANISM (THE SENSE ORGAN) THE CONNECTING MECHANISM (THE NERVES) AND THE REACTION MECHANISM (THE MUSCLE). The arrows show the direction of the nerve impulse.

ble. The receptors are usually well protected; one of the functions of the accessory apparatus is the protection of the sensitive cells.

The receptors although usually far too small to be visible to the naked eye are highly specialized. Each type is sensitive under ordinary conditions to only one kind of stimulus. The receptors in the eye are highly sensitive to light waves but are entirely insensitive to sound waves to which the sensory cells in the ear are

attuned. Neither light nor sound waves arouse any other receptors under normal conditions. Certain intense stimuli such as an electric shock, a strong chemical or a sharp blow may initiate a nerve impulse in any sense organ, but this is an unusual event and such stimuli are termed *inadequate stimuli,* although *abnormal* would be a better term. The normal stimulus—or adequate stimulus, so-called—is the one to which the sense organ is specially adapted, the one which usually affects it.

Sense Organs of Vision.—The normal stimuli for the eye are light waves; that is, wave-like movements of great rapidity conducted by a substance, ether, which is assumed to fill all space. Only light waves within certain limits—wave lengths between 760 and 390 millionths of a millimeter—are normal stimuli.

The light waves entering the eye through the transparent front surface, the cornea, are admitted to the interior of the eye through the small opening at the center of the iris, that small disc of blue, brown or other color which is readily seen. The interior of the eye is dark like a photographic camera except for light admitted through the small hole—the "pupil of the eye"—in the iris. The iris corresponds to the diaphragm of the camera. When the light is strong the photographer makes the opening small; when the light is weak he makes the aperture large. In the eye the intensity of the light itself sets up reactions that result normally in an opening of proper size. Immediately behind the iris is the lens of the eye; and behind the lens is the large cavity filled with a transparent substance of the consistency of gelatin. Between the cornea and the lens is a small cavity filled with a gelatinous transparent substance. The function of the lens in the eye like that of the lens in the camera is to bring the rays of light to a

focus on the really sensitive area. The inner rear surface of the eye, the *retina,* which has the same general location as the plate or film in the camera, contains the sensitive receptors. In these sensory cells so tiny that nearly a

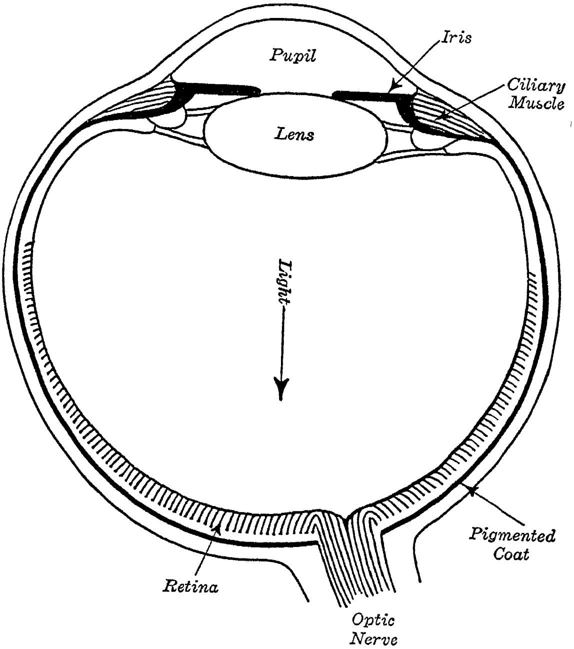


FIG. 3.—A HORIZONTAL CROSS SECTION OF THE LEFT EYEBALL. The sensory end-organs in the retina are relatively very much smaller and more numerous than here represented. See text for description and Figure 4 for an enlarged diagram of the sense organs in the retina.

million may be found in an area one-tenth of an inch square, the light arouses the nerve impulses which are conducted by nerve fibres to the central nervous system.

Only the little end organs in the retina are sensitive to light; all other structures such as cornea, iris and lens are accessory. The three pairs of muscles which move the

eyeball about in its socket are also accessory. The main purpose of the muscles is to bring the stimuli to bear more effectively upon the receptors. The bony projec-

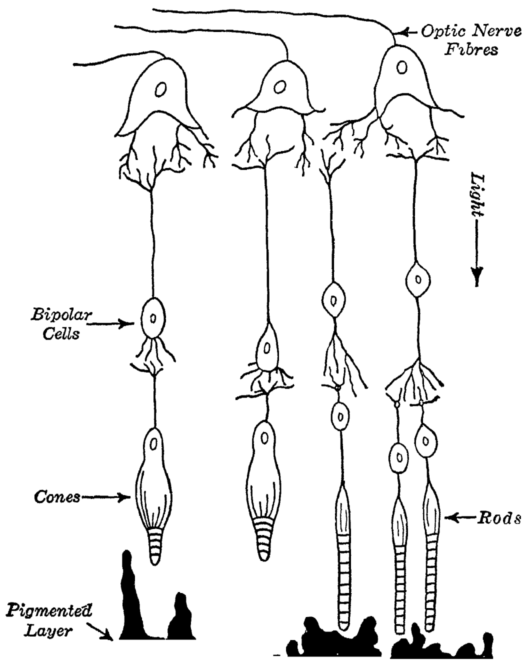


FIG. 4.—AN ENLARGED DIAGRAM OF THE SENSORY CELLS AND CONNECTED NERVE CELLS IN THE RETINA. Sight passes through the nearly transparent substance of the retina, in the direction indicated by the arrow on the right, and is stopped by the pigmented layer beneath. Just above this layer are shown the "rods" and "cones" in which are aroused the nerve impulses which are transmitted to the optic nerve fibres.

tion of brow, the quick-moving eyelid and lash and the tear glands are also accessory; their function is mainly protective.

Sense Organs of Hearing.—The adequate stimuli of hearing are wave-like disturbances set up by a vibrating

medium such as a piano string or the vocal cords, and conducted by the air or by other substances such as metals, liquids, bones or wood. The waves consist of pulsations ranging in rate from about 16 to 40,000 per

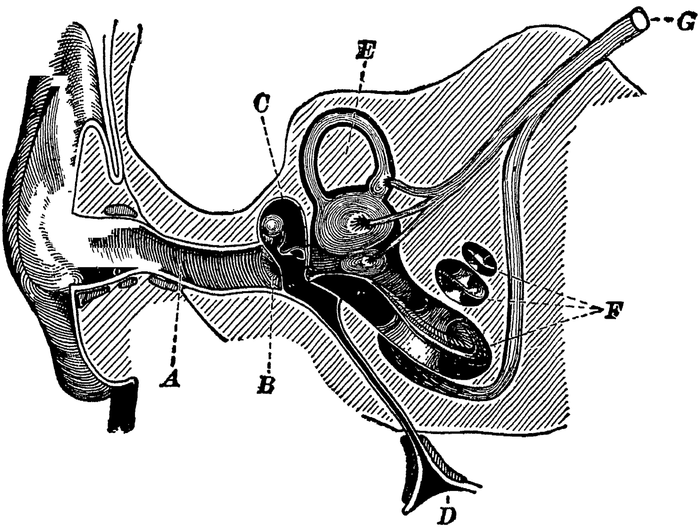


FIG. 5.—DIAGRAM OF THE EAR. Collected by the external ear, the sound is carried down the canal A and strikes the vibrating membrane B. The vibrations of the membrane are transmitted to the chain of little bones C which transmits the disturbance by means of the stirrup-shaped bone to the liquid which fills the inner ear, including the Cochlea F in which the sensory nerve endings of sound are located. E represents the semi-circular canals which contain the sense organs of equilibrium. G is the trunk of the sensory nerve. D is the Eustachian tube which affords an air passage between the middle ear and the throat. (From Angell's *Psychology*.)

second. Above and below these limits are waves to which the ear is not attuned.

Like the eye, much of the ear consists of accessory apparatus of which only the least important the external ear shell is visible. The external ear together with the hollow tube leading into the skull serve much the same

function as the speaking tube of a recording phonograph or dictaphone; that is, it collects and directs the air waves inward until they strike a stiff membrane which is stretched across the bottom of the tube. Just as the membrane in the recorder of the dictaphone takes up the vibrations and transmits them to small metal attachments at the end of which is the recording needle, so the ear membrane—the "ear drum"—transmits the pulsa-

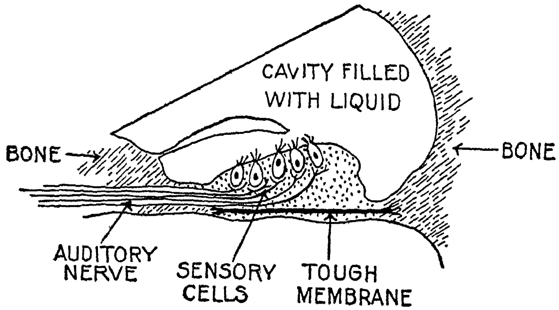


FIG. 6.—A ROUGH SKETCH OF THE SENSORY CELLS IN THE INNER EAR. The cells are imbedded in tissues which rest upon a tough membrane. It is supposed that the membrane vibrates as a result of pulsations conducted by the liquid thus stimulating the cells. The auditory nerve is shown.

tions to a series of small bones, the last of which sets into vibration the liquid in a chamber of the inner ear. In this deeply imbedded inner chamber are found the sensitive auditory nerve endings which are aroused by the pulsations of the liquid in which they are immersed.

Sense Organs of Equilibrium.—Adjoining the organs of hearing are three other mechanisms, the semi-circular canals, the utricle, and the saccule, which are responsive not to sounds but to movements of the head. These organs consist of bony cavities filled with liquid into which tiny sensitive hair cells project as reeds may project into a stream of water. Slight movements of the body

disturb the liquids whose changes of position are the immediate stimuli of hair-like sense organs. These receptors are involved in the acts of maintaining equilibrium when the body is moved in various ways as by an elevator, a ship or a street car or when it moves by itself as in walking, jumping, and stooping over. Any movement which involves the head, by its influence on these sense organs, activates nerve impulses that bring about

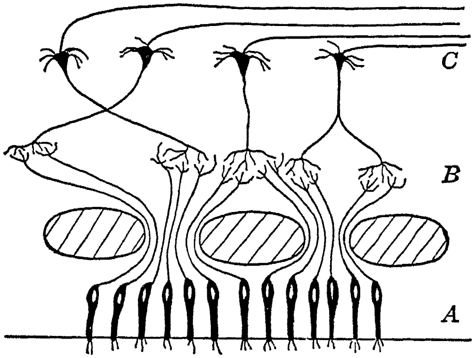


Fig. 7.—At A Are Shown the End Organs of Smell, the 'Olfactory Cells,' With Tiny Hairs Projecting Above the Surface of the Lining of the Nasal Cavity. At B the end organs connect with the nerves which run off (at C) toward the brain.

appropriate bodily adjustments. The leaning inward by the child on the merry-go-round is a reaction mainly occasioned by the effect of the movement on these sense organs of the head. When they are injured the maintenance of appropriate bodily positions under such circumstances is difficult or impossible.

Sense Organs of Smell.—In the upper part of the nasal cavity somewhat removed from the pathway of the air currents or ordinary breathing is an area, about the size of a dime, which contains a large number of receptors that are sensitive to certain chemical substances in

gaseous form. To arouse the receptors of smell the chemical substances must give off a gas, that is, dissolve in the air; mere floating particles of matter such as dust are ineffective. As yet there is no reliable information concerning the number and kinds of gases which are adequate stimuli for the organs of smell though both are probably large.

The receptors are microscopic rod-like cells lodged in the membrane with tiny hair-like fibres projecting above the surface. The elaborate accessory apparatus characteristic of the eye and ear are not found unless the nose is considered as such. Sniffing is a device for bringing the stimuli more effectively to bear on the receptors which are well protected from injury by their location.

Sense Organs of Taste.—The receptors of the taste sense are found mainly on the upper surface and along the edges of the tongue. They are often called "taste buds" since they resemble the appearance of a plump rose bud the stem of which corresponds to the nerve. Most of the taste buds are imbedded in the walls of little trenches in the surface of the tongue. Projecting into the trenches are tiny hair-like fibres which come into contact with the chemical stimuli in liquid form. These fibres are elongations of small cells which together with the nerve fibres and supporting cells make up the body of the buds. The receptors are sensitive to four classes of substances—sweet, salty, sour and bitter. Many other

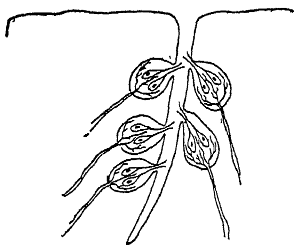


FIG. 8.—THE TASTE BUDS ARE SHOWN EMBEDDED IN THE WALLS OF A CREVICE IN THE TONGUE. The nerve endings are entwined about the cells whose fibres project into the crevice.

substances do not stimulate any of the receptors and are consequently tasteless.

Sense Organs in the Skin.—So minute and numerous are the sense organs in the skin that no one has been able to make more than an approximate inventory of them. Estimates of the number vary from three to six million. There are probably more than two million *pain receptors.* There are very simple forms of sensory endings responsive

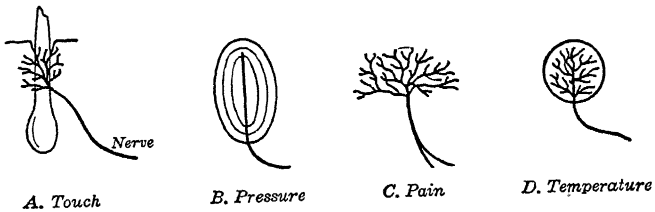


FIG. 9.—ROUGH DRAWINGS OF FOUR TYPES OF SENSE ORGANS FOUND IN THE SKIN. A is a network of fine fibrils coiled about the roots of a hair. Movement of the hair presses the fibres and thus stimulates them. B shows a nerve ending surrounded by several layers forming a capsule of a type usually found in the subcutaneous tissues. C is the finely branched nerve ending of the pain sense. D is a bulb surrounding branches of nerve endings which are probably sensitive to changes in temperature.

only to rather intense mechanical, chemical and thermal forces such as blows, severe pressure, pricks, stings, acids, extreme heat and cold. There are probably at least a half million sense organs of various shapes and sizes sensitive to *touch or light pressure.* Some of these, lying close to the surface, are sensitive to the slightest pressure of a hair or tuft of down; others, more deeply imbedded, are aroused only by more heavy pressure while many are found between these extremes. Some of the touch sense organs consist of a spray of fibrils or a coil such as those surrounding a hair under the skin surface; in others the fibrils are bunched or coiled within other

tissue forming a bulb or "corpuscle"; in others the fibrils are surrounded with layers, somewhat as in an onion, forming a "capsule." Another variety of receptors roughly similar to some of the organs of touch and numbering at least a half million are aroused by radiations of heat of a degree lower than that of the skin. These are called *cold receptors.* The *receptors for warmth* which are less numerous, thirty thousand or more, are sensitive to temperature higher than that of the skin. All of these

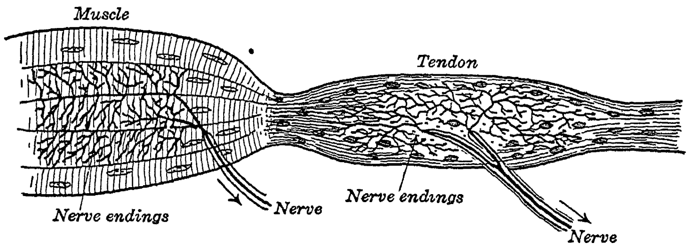


FIG. 10.—ROUGH SKETCH OF THE SENSORY NERVE ENDINGS TWINED ABOUT THE FIBRES OF A TENDON (RIGHT) AND ABOUT MUSCLE FIBRES (LEFT). The sensory endings are drawn only for three of the muscle fibres. (Adapted from Cajal after Tilney and Riley.)

sense organs in the skin contain relatively simple, if any, accessory apparatus. The layers of tissue in the capsule-like organs, the gritty tissue in some of the bulb-like organs and the hair at the base of which sensory fibrils are coiled are three samples of accessory apparatus which serve to intensify the stimulus.

Sense Organs Within the Body.—Receptors in unknown numbers running into millions without doubt are found in the inner linings of the body, the nasal membranes, the gullet, stomach and intestines, in the walls of the blood vessels; in the fibres of muscles and ligaments and the surfaces of joints; in the tissues of the lungs, glands and other internal organs. Through these sense

organs bodily conditions and activities provide stimuli which like forces of external origin cause or condition our reactions.

The receptors in the muscles, tendons and joint surfaces are of significance since they afford the most obvious illustration of equipment by means of which specific activities of the body, themselves reactions, become the stimuli which in whole or part produce other reactions. When a muscle is thrown into action the movements and pressures stimulate the receptors that entwine about or are imbedded between the slender muscle fibers. The arousal of these receptors which are connected with the central nervous systems by nerves like other receptors typically leads to some other reaction. Each bodily process, such as breathing, moving the head, limbs or fingers, depends in whole or part upon nerve impulses that are aroused in this way. One part of an act such as lifting the arm or writing a name, itself a reaction, becomes a stimulus which leads to the next segment of the act, that to the next, and so on. Movements which require any appreciable amount of time involve a series of stimuli and responses of this type.

The stimuli arising from the activity of the muscle itself, we have said, may often be a part and not the totality of the influences. Often the reaction is the result of several types of stimuli acting at once. Take walking, for example. To what is it a reaction? It is a response, or, rather, a series of responses, to many different stimuli acting at once; partly to visual stimuli obtained during careful or fleeting observations of the pathway, partly to pressure upon the soles of the feet, partly to stimuli upon the organs of equilibrium in the inner ear and partly to stimuli set up in the muscles by movements immediately preceding. The total movement of the leg in making one

step consists of a series of muscular reactions linked together as stimulus and response. Each minute segment of the swing of the leg is due to a group of simultaneous muscular acts which set off the next set of muscular responses. Similarly in playing a scale on the piano, the reactions are produced not wholly by seeing the keyboard and the fingers, by adjustments made to the sound of notes produced nor by the pressure of the keys on the finger tips, but partly—and in the case of the experienced player, mainly—by the stimuli occasioned by each little

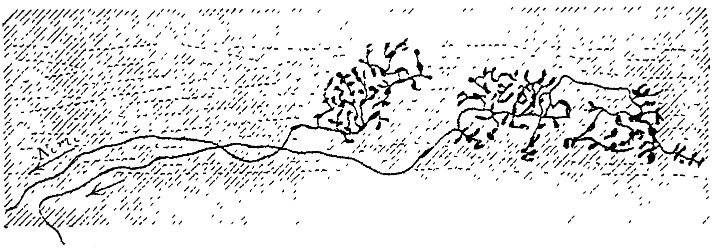


FIG. 11.—RECEPTORS FOUND IN THE WALLS OF AN ARTERY. (Adapted from Cajal after Tilney and Riley.)

segment of the act itself. Essentially all continuous muscular activity is produced, in part, by a stream of impulses which its own activity provides. A muscular act, then, is at once both a reaction and a stimulus.

Apart from muscular responses other internal activities and conditions directly affect receptors. That these receptors are numerous and of several types is known, but how numerous the individual organs, how many the types, and just what specific stimuli affect them are not known. Some of the known receptors are similar in appearance to the pressure, warm, cold and pain sense organs in the skin, but others differ more or less and many await really clear descriptions. However few or many the types of receptors may be, the variety of inner

conditions and activities which affect them is great. By "conditions" are meant the states of affairs which underlie fatigue, weariness, irritability, nervousness, nausea, ill-being, well-being, hunger, thirst, aches and the like. The exact causes of but few of such bodily conditions are known. The invasion of bacteria, disturbances in metabolism, poison, the secretions of the internal glands, deprivations, as of food or water, and muscular contractions in the heart, arteries or intestines are among the causes of stimulation.

Inner conditions and activities such as these not only occasion specific inner responses of various types, as for example when irritation in the stomach cause vomiting, but they also affect more general behavior. Familiar events of daily life are evidence. A man, arising in the morning feeling fine and fit, greets his wife and children with affection and satisfaction, enjoys his breakfast, anticipates with zest the work of the day, disregards crowding in the cars, smiles at the heap of letters on his desk. On another day, arising with a bit of indigestion or fatigue, he may be less enthusiastic about, even bored by, the same family, dissatisfied by equally good food, annoyed by the thought of the day's work; angered by the crowding, discouraged by a similar batch of correspondence. The external situation gives only a part of the total stimuli; the inner conditions may sometimes be the more potent. Such combined action of inner and outer stimuli adds immeasurably to the difficulty of understanding and predicting human behavior.

Reactions to Many Stimuli Acting at Once.

Most of the reactions with which psychology is concerned are made not to a single and simple stimulus but a combination of different forces. The man strolling

along the street or attending a concert, the child at play or in school, is subjected at once to varying stimuli through eye, ear, nose and skin, to stimuli from many internal conditions, from activities of muscles and glands, which, taken all together, make up a complex situation. The term *situation* is often used, instead of stimulus, to suggest the complexity of events; it means, strictly speaking, a complex group of stimuli. Stimulus and situation will be used interchangeably, however, throughout the book since most of the stimuli to which we respond are complex.

What is true of muscular activities is true of glandular activity but in ways that differ in detail. The action of glands, especially certain internal glands, has pronounced effects on other activities, not so much by stimulating sense organs in the gland itself as by arousing others through its secretion. Circulated widely by the blood, the secretions of the *adrenal* gland, for example, have a prompt effect upon the activities of the pupils of the eye, the heart, lungs, stomach and upon other glands, such as the salivary gland and the thyroid. Thus one of the results of glandular activity, itself a response, is the production, in part or whole, of the stimuli which elicit other reactions.

The reaction hypothesis, first stated in terms of the simplest conditions, needs no fundamental modification but merely elaboration to cover the responses to complex situations. It will be necessary, first, to show how the reactions are brought about by the combined effects of many stimuli acting at once. For this purpose, the way in which the nervous system conducts nerve impulses from many sources into one or more reacting mechanisms must be shown. This explanation will be offered in the next chapter. It will be necessary, later, to

enlarge the group of stimulating factors to include conscious activities, memories, ideas, emotions, purposes. When these processes are added to the activities of muscles and glands, and other internal conditions and external forces as stimuli, we shall be ready to explain human behavior in complex form in accordance with the reaction hypothesis.

QUESTIONS AND EXERCISES

1. Compare the control of activity in the body with the control of machinery in a big factory operated by electricity? What corresponds to stimulus, nerve impulse and reacting mechanism? In what respects are the two quite unlike?
2. Is human reaction more like that of a football when kicked or that of a gasoline engine? In what respects is human reaction unlike either?
3. If the reaction hypothesis is accepted, would it be necessary to assume that ideas could never lead to activity? Explain how the thought of candy might lead to response of the salivary gland in accordance with the reaction hypothesis.
4. Give some illustrations in which more than one stimulus is concerned in activating a reaction.
5. When it is stated that a conscious state is a reaction, just what is implied?
6. What sense organs are stimulated by: (1) smoke from a hot furnace; (2) lifting a weight; (3) running after and returning a tennis ball; (4) eating an onion; (5) reciting aloud to yourself?
7. Can you name some forces or substances to which we are insensitive, i e., which influence no sense organ? How is it possible to discover that there are air waves which do not arouse the ear and ether waves that do not arouse the eye? What instruments or procedures mentioned in Chapter I might be utilized for such purposes?
8. Are the usual eye defects found in the accessory apparatus or the receptors proper?
9. As animal species evolve more complex and numerous reacting mechanisms would there of necessity be an increase in the complexity and number of the receptors? Why or why not?

10. What stimuli are operating when a man rides a bicycle along an irregular road?
11. Why is such a term as "abnormal" or "unusual" to be preferred to "inadequate" stimulus?
12. What sense organs are most indispensable to the life of man? What least?
13. Has man only the "traditional five" senses?
14. Mark the following statements *true* and *false*.
    a. All of the sense organs are on or near the surface of the body.
    b. According to the text, all mental activity may be considered as a reaction to definite stimuli.
    c. A stimulus is that force or activity which arouses a reaction.
    d. The term situation applies to a very simple stimulus.
    e. The bodily reaction never involves the expenditure of more energy than was transmitted to the organism by the stimulus.
    f. Bodily reactions are often caused by several stimuli acting at once.
    g. The ear as a whole is called the receptor.
    h. Some sense organs have no connections with nerves.
    i. The reaction of one mechanism is usually a part or whole stimulus to other reactions.
    j. The accessory apparatus is that part of the sense organ which is specially sensitive to the stimulus.
    k. There are at least four different kinds of sense organs in the skin.

GENERAL REFERENCES

Other accounts of the reaction hypothesis will be found in E. L. Thorndike, *Elements of Psychology,* New York, A. G. Seiler, 1905, and *Educational Psychology, Briefer Course,* New York, Teachers College, 1914, and in R. S. Woodworth, *Psychology,* New York, Henry Holt, 1921.

More detailed descriptions of the sense organs will be found in John Watson, *Psychology*, Philadelphia, Lippincott, 1919, and in G. T. Ladd and R. S. Woodworth, *Elements of Physiological Psychology,* New York, Scribner, 1911.

CHAPTER III

THE CONNECTING MECHANISMS

The Main Features of the Nervous System.—A stimulus starts in the sense organ a nerve impulse which eventually occasions a response. Between the sense organs and the organs of response is a series of connecting links called *neurones* which constitute the nervous system. First in order are the *sensory neurones*, distinguishable by the fact that they always originate in a sense organ and lead to the central nervous system which is encased in the backbone and skull. From every sense organ, from every tiny receptor in the skin, in the muscles, internal organs, the eye, ear, tongue, etc., run the delicate thread-like fibres of the sensory neurones to the central system.

The *central nervous system* comprises the brain which occupies the large cavity in the skull; the brain stem and cerebellum at the base of the skull; and the spinal cord which fills a long slender hollow in the backbone. Most of the sensory neurones from the receptors in the head enter the central system through the brain stem at the base of the skull. The sensory neurones from the remainder of the body enter the spinal cord at levels which correspond to the levels of the sense organs in the body; that is, those neurones from the lower limbs enter at the lowest portions of the spinal cord, those from the upper limbs at the upper levels of the cord, and those from the trunk at intermediate levels.

The central system is a switching station of tremendous complexity. It consists of millions of neurones which form interconnections between the sensory and the *motor neurones.* The motor neurones are those which, issuing from the brain stem or spinal cord, run to the various organs of response, such as the muscles of the head, arms, trunk, limbs, feet and internal organs. The neurones which carry the nerve impulses from the sensory to the motor neurones are called *central neurones* or *interconnecting neurones.*

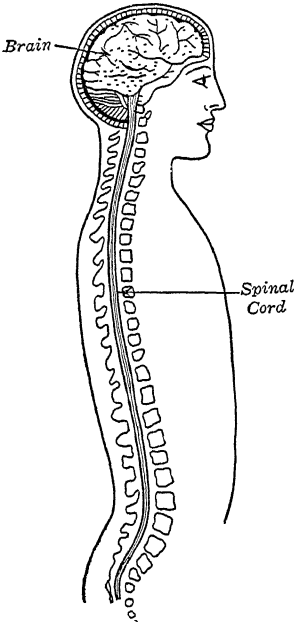


FIG. 12.—A GENERAL VIEW OF THE BRAIN AND SPINAL CORD. The midbrain begins at the base of the skull but is mainly covered by the brain The spinal cord as here represented is relatively too large; its actual diameter is about that of a pencil.

There are millions of neurones of each of the three types—sensory, central, and motor—but the central neurones are by far the most numerous, so complex is the interconnecting system. It is probably the most complex structure in nature. To count the neurones in the body, assuming a rate of two per second for eight hours a day, every day in the year, would require at least a thousand years.

STRUCTURE AND FUNCTION OF THE NEURONES

Although differing greatly in size, shape, and complexity, the neurones are alike in certain important re-

spects. They always include a *cell body* and a number of fibres. The cell body is a small but complex structure essential to the life and function of the neurone as a whole. The long, wire-like fibres which conduct the nerve impulses from one place to another are called *axons.* Thus, from a sense organ on the foot, an axon

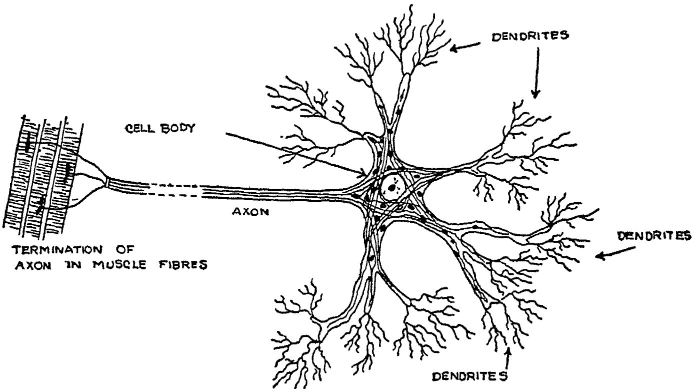


FIG. 13.—A MOTOR NEURONE HIGHLY MAGNIFIED. The axon is sometimes several feet long.

runs up through the leg and hip until it reaches the spinal cord just below the waist line. Usually a number of axons from adjacent sense organs are grouped together to form a nerve as telephone wires are collected to make a cable. All of the central neurones contain axons which run from one part of the central system to another, sometimes for very short, sometimes for long, distances. The axons of the motor neurones are the long processes which connect the organs of response with the central system.

The central neurones and the motor neurones contain a bushy group of relatively short fibrils called *dendrites,* whose function it is to pick up the nerve impulse from other neurones. The sensory neurone discharges its

nerve impulse into the spinal cord by means of its axon, entering the central system. The dendrites of central neurones either come into contact or into close proximity with the discharging end of the sensory axon from which they receive the nerve impulse. The dendrites usually converge at the cell body out of which the axon leads to the dendrites of other neurones. In the case of the motor neurones, the dendrites lead to the cell body from which the axon conducts the nerve impulse to the organs of response. The dendrites, then, receive, whereas the axons carry on and discharge the impulses. The sensory neurones do not receive from other neurones and consequently have no dendrites. They consist of the end organs in the sensory apparatus, the long axon, and, of course, the cell body which is usually near the discharging end of the neurone.

The Synapse.—We must give special attention to the junction between two neurones, the place where the axon endings of one neurone reach the dendrites of another—a place called the *synapse*. The axon endings and the dendrites do not actually unite or fuse; they simply come into contact or into more or less close proximity. Neurones are independent units, like trees growing with branches close together or intertwined. Each tree is independent, touching but not joined to one or more others. The association of neurones at the synapse is of this character. The synapse, then, is not an organ or thing but merely a place where axons and dendrites come into contact or are close together.

The nerve impulse makes its way across the synapse when conditions are favorable, always from axon to dendrite, never in the opposite direction. Typically the endings of the axon make contacts with the dendrites of many different neurones; that is, there are many syn-

apses, but usually the nerve impulse follows but one or a few of the possible pathways. At some synapses great resistance is offered to the passage of the impulse; at others, relatively little. The impulse crosses only those synapses where the resistance is low. Thus the degrees of resistance offered at the synapses (or synaptic connections) determines the course a particular nerve impulse will take and, in effect, what reactions will be made.

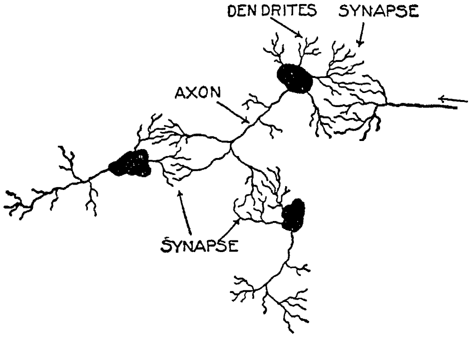


FIG. 14.—A SERIES OF NEURONES SHOWING SYNAPSES OR SYNAPTIC CONNECTIONS.

What makes the resistance high at some synapses and low at others is not known. It may be the spatial proximity of axon endings and dendrites, the inner composition of the fibrils, or some other condition.

The nerve impulses, because of conditions which must at present be described rather vaguely as differences in resistance at the synapses, do not become scattered and diffused throughout the whole bodily equipment of reacting mechanisms. On the contrary, they take particular, limited courses and evoke responses in certain organs only. There are predetermined routes from particular sense organs; routes determined by conditions at the synaptic connections. Some of these routes are short;

some are roundabout; some are inherited just as bones and eye-color are inherited; some are acquired through experience as wrinkles and table manners are acquired.

Levels of Organization of Connections.

Routes and Reactions of the First Level.—The simplest stimulus-connection-response unit (which may be designated by the symbols $S \rightarrow R$ or $S — R$.) consists of a sensory neurone, a central connection, a motor neurone, and a muscle. Stimulation of the sensory neurone results in a response by the muscle. Thus a slight prick of the skin on the finger or eyelid would cause a contraction of a local muscle. There is always a slight interval between stimulus and response, since some time—1/30 of a second at least and sometimes as much as 1/5—is required for the nerve impulse to get under way, to complete the route to and from the central system, and finally to arouse the muscle. Such a simple and relatively prompt $S \rightarrow R$ unit is often called a *reflex arc,* the reaction a reflex act or a reaction of the first level.

Usually the reaction is not so simple, but involves several muscles. Each sensory neurone makes connections with many effectors by means of central neurones in the cord. Not all of these will be activated, but usually a limited number, depending on the resistance encountered at the synapses, will be activated.

A great many reflexes or reactions of the first level may be observed in an infant very shortly after birth. A prick on the infant's foot elicits a quick jerk of the leg. Uncomfortable stimuli such as tickles, pricks, heat, or cold applied to other parts of the body provoke prompt avoiding reactions. An object striking the cornea causes the wink reflex. Milk in the mouth causes a gush

of saliva, a glandular reaction. Food on the back of the tongue causes a swallow; food in the stomach, gastric secretions and movements. A slight tickling of the nasal membrane causes a sneeze; an object on the palm of the hand, the grasping reflex.

All of these reactions are relatively simple, involving only the most direct routes (reflex or first level routes) through the central system, and activating a relatively small number of reacting mechanisms. These reactions

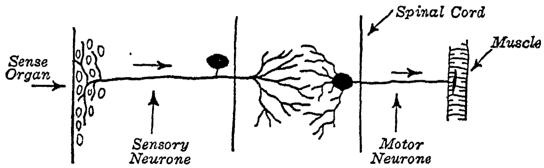


Fig. 15.—The Mechanisms and Connections Involved in a Reflex Act or a Reaction of the First Level.

are very prompt and certain, and for this reason they may be fairly safely predicted. They are uniformly found in normal infants, and since they can be modified or inhibited only with greatest difficulty, they persist usually throughout life. For these reasons, tests of the first level reactions have become an important feature of the diagnosis of disorders of the nervous system.

Routes and Reactions of the Second Level.—In addition to traversing one or more of the innumerable pathways of the first level, a nerve impulse started, for example, by a pin prick on the foot, may make its way to routes of a higher level which are contained in various parts of the central system, located at the base of the skull, continuous with the spinal cord, and covered by the masses of the brain proper. Much of the brain stem which is subdivided into many parts, and certain neigh-

boring appendages including the cerebellum are devoted to connections of the second level. The portions of the brain included in this region we shall call the mid-brain and we shall speak of the responses as reactions of the second level or of the mid-brain level.

We observed that a sharp stimulation of the toe causes a jerk of the foot, the simplest reaction. Perhaps also movements of the hips, trunk, or arms occur—reactions which probably involve only connections or routes of the first level. In some cases, especially if the stimulus is a strong one, the subject may turn the head, readjust his equilibrium, gasp or shout, and show internal changes such as an increased respiration and heart beat. These reactions involve more complicated connections—connections of the second level—which are located in the mid-brain section. These routes are shown diagrammatically in Figure 16.

Reactions of the second level are said by many authorities to be instinctive or unlearned. Although there is some disagreement upon this point, it is certain that many of them are unlearned because they may be obtained in the newly born infant. If you hold the infant's nose, he first jerks slightly (first level) but later moves up his hands, pushes at the offending object, and later kicks, yells, squirms, and grows red with anger. Place the infant's face in the pillow, he will attempt to draw the head back (first level probably) and shortly kick, move his arm, squirm, and perhaps succeed in turning around. Such reactions as turning the head to sounds or moving arms up to things seen, or such complex inner reactions as appear during anger and fear, are usually second level reactions.

Reactions of the second level, as contrasted with those of the first level, as a rule take place in a part of the

body somewhat more distant from the point of stimulation, and they are somewhat more complex, somewhat less rigid, less invariable and more readily modified. These distinctions are not sharp, however, and only the expert in neuro-anatomy is able to distinguish the levels involved in many reactions.

The mid-brain connections form complex pathways

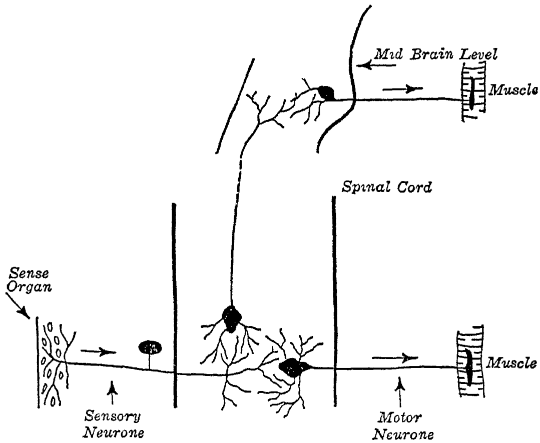


FIG. 16.—THE CONNECTIONS INVOLVED IN REACTIONS OF THE SECOND OR MID-BRAIN LEVEL. The neurone which runs up to the mid-brain and another which runs from the mid-brain to the muscle are added to those of the first level as shown in Figure 15. The broken line indicates that a large section of the cord has been cut out.

between different incoming and outgoing neurones, thus providing joint reactions to several stimuli received at once. Walking, stooping, running, jumping, and other complex bodily activities are responses made to many stimuli—from the organs of equilibrium in the skull, from the eyes, from the soles of the feet, muscular pressures in many parts of the body—which are pouring in at the same time. The mid-brain section provides in part for combination and redirection of these numerous

impulses into motor nerves that provide coordinated and effective adjustment. Instead of many relatively independent and unrelated reactions, harmonious joint responses are thus secured.

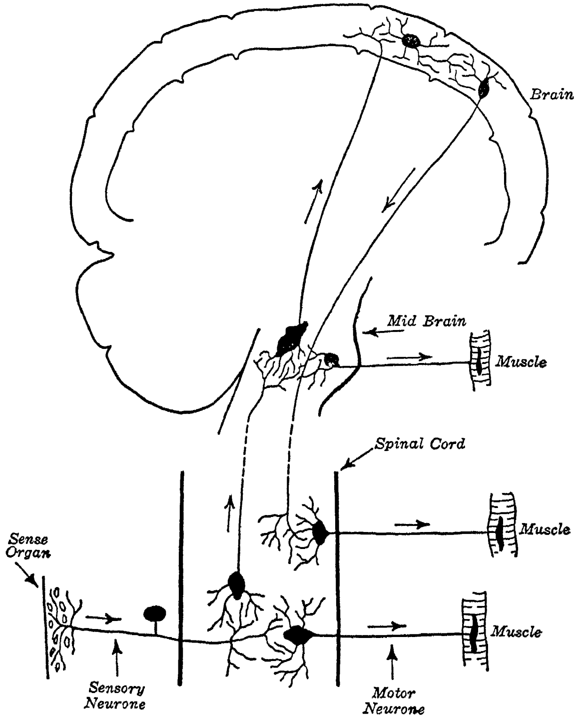


FIG. 17.—CONNECTIONS OF THE FIRST, SECOND AND THIRD LEVELS. The arrows indicate the direction of the nerve impulses. The area between the two lines at the top of the brain represents the cortex. See text for fuller explanation.

Routes and Reactions of the Third or Brain Level.— The larger portion of the brain consists of the two *cerebral hemispheres,* or *the cerebra* which we have hitherto spoken of as the brain proper, as contrasted with the midbrain section which includes the brain stem and cere-

bellum. By means of a chain of neurones, a nerve impulse originating at any sense organ may finally reach the surface or cortex (literally the bark) of the brain, which consists of a tremendously complicated network of neurones. The portion first reached by the incoming impulses is called the *sensory area*. From the sensory areas connections are made with the *motor area* where exist almost limitless possibilities of connections with other central neurones, by means of which effectors in any part of the body may be reached.

Reactions of the brain level may be of any degree of complexity, involving few or a great many effectors near to, or remote from, the point stimulated. We found the immediate withdrawal of the toe or foot, when it is pricked, to be a reaction of the first level; the more general bodily readjustment, in turning of the head, the cry of pain, changes in respiration, etc., to be second or mid-brain level reactions. To apply camphor to the injured spot or to examine it deliberately would involve neural connections in the cortex. All learned reactions, so far as we know, depend upon connections established in the brain or cortical level. It has been fairly well demonstrated, for example, that the ability to speak or write words, both of which reactions are clearly acquired, can be seriously impaired or destroyed by removal or injury of certain portions of the cortex of the brain.

We have illustrated roughly the possible distribution of nerve impulses. Just what effectors will be aroused depends upon the conditions at the synapses. Certain synapses in the course of an impulse from any particular receptor, will be found to be "open," that is, to offer little resistance as a result of one's inherited organization. In this way, the unlearned or instinctive reactions, which involve mainly, and probably wholly, connections in the

spinal cord and mid-brain, are accounted for. The relative openness of other synapses, particularly of those in the brain, is determined by the experience and learning of the individual. In fact, all learning consists in the modification of synaptic connections by the passage of nerve impulses across them. The exact nature of the nerve impulse, now supposed to be an electro-chemical process, is not known, nor is the character of the changes in the synapses brought about by the passage of impulses. A fundamental assumption of physiology, however, is that the transmission of nerve impulses does change the condition of the synapse in a way that makes subsequent passage more easy, certain and prompt. This change brought about by exercise is sometimes spoken of as lowering the resistance, causing greater openness or permeability of the synapse, or in other ways. All of these expressions imply the same general hypothesis.

The Operation of the Nervous System as a Whole.

Diffusion of Nerve Impulses.—The nervous system is so organized that an impulse, initiated at any receptor, may make its way to many, perhaps to all, reactors. If all switches (synapses) were open, any stimulus might produce all the responses of which the body is capable. An approximation to such diffuse reaction can be shown in a simple experiment. If we prick the foot of a frog with a stiff hair or a pin, the usual response is a slight jerk of the leg. A second stimulation of the same spot will provoke a bigger response of the leg; a third stimulus may bring the other leg into action, and further stimuli will show a spreading of response until the whole organism, probably every muscle and gland, is involved. The diffusion of response is secured more readily when a

bit of strychnine, which lowers the resistance of synapses, is injected before the experiment is begun. Such diffusion of nerve impulse is, of course, not usually the case and never occurs except under extraordinary con-

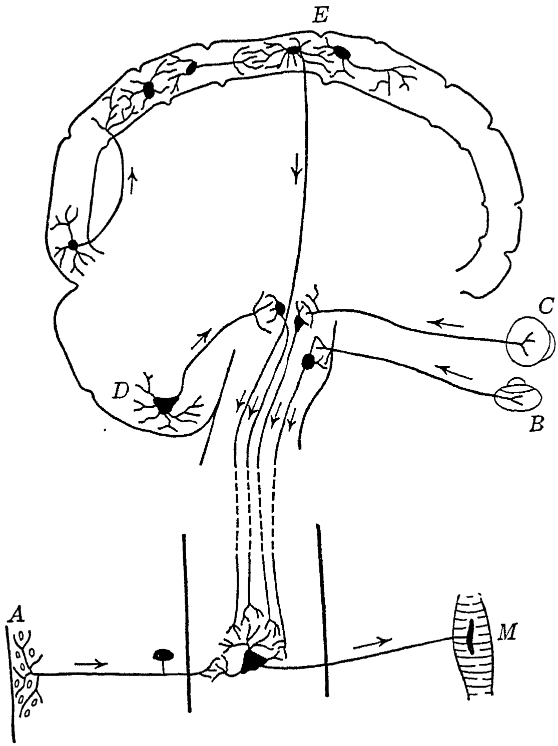


FIG. 18.—CONNECTIONS BY MEANS OF WHICH THE MUSCLE M MAY BE ACTIVATED FROM DIFFERENT LEVELS. See text for explanation.

ditions, but it proves the general statement that from each and every receptor, pathways may be made through the nervous system to each and every organ of response.

The Convergence of Nerve Impulses.—The organization of the nervous system which has been sketched provides not only for the possibility of the passage of a

nerve impulse from one receptor to almost all reactors, but for the convergence of impulses from many receptors upon one effector. That convergence, as well as diffusion, is provided for may be illustrated by an experiment upon a frog. A very gentle prod on the foot with a stiff hair may elicit no response, but when a slight sound is made simultaneously, the foot may jerk as it would for a more intense stimulation with the hair. If these two stimuli prove insufficient, a small flash of light added to the combination may cause the foot to jerk. The nerve impulses aroused in different parts of the body seem to have come together and combined their energy on the muscle in the foot. A light, a sound, and a prick on the foot are about as unrelated as any three stimuli could be, and if the impulses from these can be converged on the same effectors, it is probable that nerve impulses from any or all receptors may find their way to any particular effector. Indeed, this would follow as a necessary corollary of the fact of diffusion of impulses previously illustrated, i.e., the fact that from one receptor impulses may reach any given effector.

The mechanism of convergence is illustrated in Figure 18. Suppose muscle M to be in the foot. It may be aroused by a stimulus, such as a pin prick which affects sense organ A in the vicinity of the muscle. The reaction would be a reflex. Impulses received from B, the ear, or C, the eye, by means of connections in the midbrain level may also discharge into M. In everyday experience this occurs in many of our bodily adjustments brought about by things seen or heard. When we are startled by sudden sounds, when we shift our equilibrium on observing an obstacle, or halt at a strong odor, the mid-brain level is involved. In most of our complex motor adjustments, connections in the cerebellum

(illustrated by D) are also utilized. E represents a neurone originating in the motor cortex of the brain, and connected by motor neurones with the muscle M. Impulses from various parts of the brain (indicated by several neurones) may reach E and eventually discharge into the muscle M. Thus the response of M as part of any learned act, such as dancing, putting on a shoe, etc., is accounted for as well as what is usually called voluntary control—the arousal of M by an "act of will." Voluntary action is acquired action, not to be sharply distinguished from learned reactions in general. A particular muscle, then, may be activated by impulses which come from many sources directly through connections in the spinal level, from other sources through connections of the mid-brain level, and from still other sources through the cortical level.

Facilitation.—Since each muscle has fairly close connections with a number of sense organs, the stimulation of two receptors will produce a more prompt and vigorous response than the stimulation of one; three will be more effective than two; and so on. The energy from one impulse adds something to the effectiveness of the energy of others activated at the same time when all have more or less "open" pathways to a common effector or group of effectors. This is the phenomenon of *facilitation.* The neurologist is often able to select at different points on the body the several sensory endings from which impulses lead rather directly to a particular effector; that is, he knows where to apply stimulation to secure relatively pronounced facilitation. The possibilities of facilitation are shown in Figure 18 and everyday life affords other true, but less precise examples. If one is frightened while walking alone at night, one tends to speed up a little on slight stimuli; a crackle, the chirp

of a night bird, or the sudden perception of a dark object may stir us to flight. The sight of food on the table added to the odors and sounds from the kitchen, makes our hunger more acute. We shout at the horse, in addition to other stimulation, to get the greatest action. Thus, when two or more stimuli, each having a similar influence on common effectors, are given at once, each facilitates the others with the result that the response is more certain, prompt, and vigorous.

Inhibition.—Ordinarily a resting muscle is in a state of partial contraction or *tonus,* as it is called; and so far, we have considered only the influence of one or more stimuli in producing a greater contraction or a positive response. An equally important function of a stimulus is to arouse nerve impulses that depress the partial contraction, or tonus, or suppress it altogether. The application of certain chemicals, such as salt, to the cut surface of the spinal cord, will cause a relaxation of certain muscles which are then aroused to activity only by very strong stimulation until the salt has been washed away. This is the phenomenon of *inhibition.* The usual jerk of the leg when an animal's toe is pinched may be depressed or inhibited by stimulating, at the same time, an appropriate spot on the other leg. A familiar sample of inhibition is the suppression of a sneeze by pressure on the upper lip. Inhibition in the strict sense is more than mere blocking or prevention of a response; it involves a positive depression or reduction of the activity or tonus previously existing in the effector. There are different degrees of inhibition as there are of contraction, and the former is quite as much a reaction to definite stimuli as the latter.

The nature of the nerve mechanisms upon which inhibition depends is not well known. In the case of the

heart, at least, there are distinct sets of inhibitory neurones, but that all muscles and glands possess one set of neurones for stimulation and another for inhibition has not been demonstrated. Some authorities hold that the same neurones may conduct two kinds of impulses, one producing contraction, the other inhibition. However this may be, it is recognized that practically all effectors may be inhibited as well as stimulated. Combination of facilitations and inhibitions adds greatly to the flexibility of bodily reaction; it provides for a wider variety of adjustments.

Reciprocal Innervation.—Most bodily reactions involve both stimulation and inhibition so balanced as to yield the smoothest activity. For example, when the forearm is raised from the elbow one set of muscles, the biceps, contracts, whereas another set, the triceps, whose contraction would straïghten out the arm, is inhibited and so relaxed. If the biceps are stimulated artificially, by applying an electric current to their motor nerves, the triceps are innervated to inhibition. This phenomenon is called *reciprocal innervation.* Everywhere in the body muscles are arranged in antagonistic groups. Bending forward is antagonistic to bending backward; turning the head to the right to turning the head to the left; opening the hand to closing the hand; pulling to pushing; swallowing to spitting; and in the case of heart, lungs, stomach and glands, increased activity is antagonistic to decreased activity. All complex movements, such as writing, dancing, boxing, involve reciprocal innervations in great complexity. When thrown into action, each muscle by means of its sensory neurones innervates other muscles, some to increased activity, others to diminished activity or complete inhibition. The result is greater smoothness, coordination, and flexibility.

Integrative Action of the Nervous System.—The phenomenon of reciprocal innervation brings us close to one of the most important characteristics of neural action, namely, the tendency of the nervous system toward integrative action. By integrative action is meant the tendency of the nervous system to work as a unit rather than in innumerable separate parts. The various nerve currents flowing through the system tend to be welded together into one complex group which possesses a certain unity. Integrative action is unifying action. The result of the unification of nerve discharge is a tendency for the body to respond as a whole, as a unit, to the predominant stimulus acting upon it. The organism's activity, in other words, tends to be integrated or organized into a whole of related parts. This fact may be clarified by illustrations.

The examples of the "instinctive" behavior of infants given a few pages above, show reactions that are often complex, involving movements of the head, arms, fingers, and perhaps legs, trunk, mouth, vocal and internal organs which are really fairly well organized and constitute a general bodily response to the stimulus. When the child reaches to grasp an object, a certain coordination and integration of muscles in many parts of the body is found. A very young chick, when first presented with grains of wheat, pecks with fair accuracy, and in pecking from a standing position most of the body is engaged. Unless the many movements were beautifully coordinated, the chick would lose its balance, or fail to guide the beak to the right place or fail to open it at the right time, or start to straighten up before the wheat was reached. To carry out the act, all of the subordinate reactions must be highly integrated. Facilitations of same and inhibitions of other responses and many recip-

rocal innervations are combined into a working whole. The typical reaction is a highly integrated one, at least in these and other instances of adjustments that are mainly instinctive or inherited.

In acquired responses the same integrative action is also found. When a man catches a baseball, not only are many muscles of the arms and hands engaged, but also muscles of the eyes, neck, trunk and legs, changes in breathing and often other internal activities are found. To catch the ball, all of these must play properly their part in a unified whole adjustment. They must be integrated. Ofttimes the "muff" of the ball is due to some very small divergence of eye, or foot or finger. Well perfected reactions are highly unified. In learning to skate, dive, write, indeed, in acquiring all abilities, the nervous system progresses toward an integration of many constituent reactions. No characteristic of nervous action is more important than the tendency to unify the nerve currents to produce an effective total response to a stimulating situation.

Integrative Action in "Attention."—The integrative action of the nervous system explains also the characteristics of conscious reactions, characteristics usually discussed under the term *attention.* Attention is not a power or faculty but a term used to cover certain facts, as follows: (1) the organism is usually adjusted as a whole to some one thing or event, that is, to some one situation. This adjustment includes proper fixation of the sense organs and of the body generally to receive most fully the effects of the stimulus. (2) The situation to which one is adjusted—toward which one takes the "attentive attitude"—becomes more highly conscious than anything else. This situation is the one to which some further response—approach, grasp, avoid, or observe

further or neglect—if the situation does not possess the importance it promised—will be made. This situation which is at the "focus" of consciousness, is the one of supreme significance at the moment. That the organism, as a whole, is oriented toward the "object of attention" and that this object becomes conscious in the highest degree to the subordination of awareness of everything else, can be explained only by saying that the action of the system as a whole, including those mechanisms which underlie consciousness, is integrative action. Due to properly coordinating facilitations here and inhibitions there, we become conscious not of a thousand and one different and unrelated things each in equal degree, or in degrees determined by the physical strength of the stimuli, but we become aware chiefly of some unified impression. This is the main fact usually implied by the word attention.

The whole discussion of the action of the nervous system leads to the significance of integrative action. All other characteristics are subordinate to this tendency of the system to produce an effective, total response to the dominant situation. We shall encounter this fact repeatedly in later chapters.

QUESTIONS AND EXERCISES

Matching test. Read the phrases 1, 2, etc., and the sentences A. B., etc., which give concrete illustrations of the numbered concepts. Place the digit beside the letter with which it should go.

1. First level reaction.
2. Facilitation.
3. Inhibition.
4. Reciprocal innervation.
5. Second level reaction.
6. Third level reaction.

A. Just as my lips were parting to call her by name, the door suddenly slammed and I fairly screamed, "Fannie."

B. Placing your finger on the upper lip is said to relieve the impulse to sneeze.

C. Smoke always makes my eyes water.
D. As she thought of the tragedy, the tears began to flow anew.
E. The voice frightened the child so badly that he burst into tears immediately.
F. Why does one not need deliberately to decide what each muscle must do while skipping a rope?

For discussion.

1. Explain how it is that to each stimulus the response is limited rather than diffused.
2. When electric currents are applied to certain portions of a dog's brain, the dog may bark, move his front foot, or scratch with his rear foot. Diagram the nerves involved.
3. If, in Figure 18, the nerves just above the "Mid-Brain" arrow were cut off, would the individual be paralyzed entirely? What would be lost? Observe Figure 18. Where would you cut a nerve to cause complete paralysis of the muscle?
4. Do you see any reason depending on some one or more functions of the connecting system for the relatively huge size of the brain of man as compared to that of animals? If not, study pages 66 to 70.
5. What level is probably involved in such reactions as: (a) a horse stopping at "whoa"; (b) persistent sneezing during the "hay-fever" season; (c) palpitations and shock at a sudden noise when one is dozing; (d) catching a "fly-ball"; (e) dodging a ball seen just before it reached you; (f) "ducking" the head while practicing baseball when a shout of "Look-out" arises; (g) fainting at the sight of blood.
6. If a man were six feet tall, where and how long would be the longest motor neurones?
7. The axons vary from about 1/2,000 to 1/100,000 of an inch in diameter. Would a single axon be visible? Are they ever joined together in a cable? What is such a cable called? What function might be served by such a union?
8. Define the following terms: axon, synapse, dendrite, nerve resistance, diffusion, convergence, facilitation, inhibition, reciprocal innervation, connection, sensory neurone, motor neurone.
9. Draw from memory outlines of the three levels of reaction.
10. Draw a diagram showing the fact of convergence of several pathways on one reacting mechanism.

GENERAL REFERENCES

More detailed accounts of the nervous system will be found in: C. J. Herrick—*An Introduction to Neurology,* New York: Second Edition, 1918; G. T. Ladd and R. S. Woodworth, *Elements of Physiological Psychology,* New York: Scribner's, 1911; Knight Dunlap, *An Outline of Psychobiology,* Second Edition, 1920, and in J. D. Lickley, *The Nervous System,* New York: Longmans Green, 1913.

The author has found useful the very detailed account by F. Tilney and H. A. Riley, *The Form and Functions of the Central Nervous System,* New York: Hoeber, 1921.

CHAPTER IV

THE REACTING MECHANISMS

Human behavior, according to the Reaction Hypothesis, is the result of the responses of three general classes of mechanisms, the muscles, glands and certain neurones in the brain. Thus far, in discussing reactions, one type of muscles, the striped muscle, has been used mainly for purposes of illustration. In the present chapter, a brief survey of other mechanisms of response will be presented together with certain considerations to show how the activities of all of them become most intelligible in terms of the Reaction Hypothesis. The effectors will be taken up in the following order:

(1) Muscles, whose reactions produce movements.

(a) Striped or skeletal muscles.

(b) Smooth muscles.

(2) Glands, whose reactions produce chemical secretions.

(a) Duct glands, such as the salivary gland.

(b) Ductless glands, such as the adrenal.

(3) Cortical neurones, *i.e.*, neurones in the cortex of the brain, whose activity is essential to states of consciousness such as sensations and images.

THE MUSCLES.

Structure of Striped Muscles.—The *striped* or *skeletal* muscles, which constitute a considerable part of the body, vary tremendously in size from large ones in the shoulders

and legs to small ones attached to the eyes or vocal organs. Each muscle consists of a number of thread-like cells, the *muscle fibres,* which lie parallel to one another—hence the striped appearance. Each fibre is supplied with fibrils from the discharging end of a motor neurone. It is by this means that the nerve impulse, coming from the spinal cord, produces the contraction or relaxation (inhibition) of the muscle.

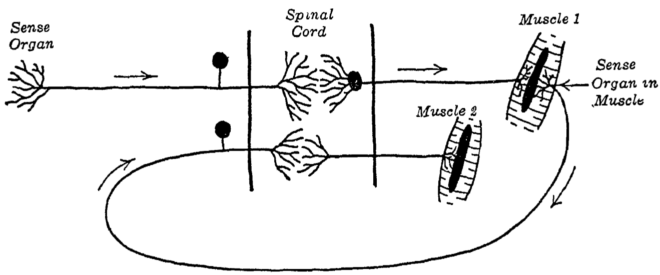


FIG. 19.—DIAGRAM OF THE NEURAL CIRCUIT. The figure, from the sense organ to muscle 1, is the usual reaction arc. When muscle 1 contracts, the sense organs within it are stimulated, resulting in the arousal of a nerve impulse which enters the cord and crossing the synapse, reaches muscle 2. Muscle 2 may arouse another reaction (connections not shown in diagram) and so on.

The Neural Circuit.—Each muscle, as we observed in the preceding chapter, is equipped with receptors, as well as with the endings of motor neurones. The contraction or relaxation of a muscle stimulates the receptors thus sending to the cord by sensory neurones nerve impulses which may result in other reactions, in the same or in other muscles. The nerve connections involved, shown in Figure 19, constitute what is usually called a *neural circuit.* It gives in simplest form the basis of continuous activity, of activity leading to further activity as illustrated under reciprocal innervation and at other points in the preceding chapter.

Any posture of a part or whole of the body maintained for an appreciable time illustrates also the operation of the neural circuit, one activity leading to others. When one holds a pen, stands or sits in one position, keeps the eyes fixed on one point in space, many muscles are continuously in contraction while others are actively inhibited. (That these postures are really states of high

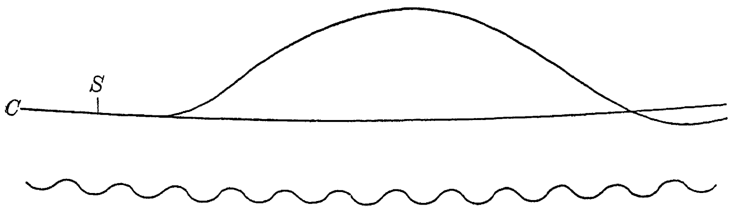


FIG. 20.—GRAPHIC RECORD OF A SIMPLE MUSCULAR CONTRACTION. A marker, playing on a swiftly moving paper, is attached to the muscle. S indicates the point at which the electric stimulus was given. As the muscle contracts the curve rises; as it relaxes, it falls. The waves at the bottom are made by a tuning fork which vibrates 100 times per second.

activity is indicated by the fact that many are very fatiguing.) The continuous contractions and inhibitions are produced by series of intermittent nerve impulses, twenty or more per second, whose rapidity is too great to permit a return to the state of tonus between stimuli. In old age, the rate of discharge may slow down until each response is perceptible, as in the shaking of the hand supporting a tea cup.

Speed of Muscular Reactions.—The speed with which a muscular reaction may follow a stimulus varies greatly according to the muscle selected, to the receptors to which the stimulus is applied, or to the conditions at the synapses in the neural pathway. When a stimulus such as an electric current is applied directly to the trunk of the motor nerve near its entrance to the muscle, there is

always a certain interval—about 0.01 of a second, more or less—before the muscular contraction begins. The typical muscular contraction requires some time to reach its maximum—0.04 of a second, more or less—after which it relaxes to normal in about equal time. When the stimulus is applied to a sense organ, rather than directly to the motor neurone, the interval between stimulus and response is greater. The wink reflex which is among the quickest requires about 0.06 of a second. Some time is required for the arousal of the sense organs and for the passage of the nerve impulse through the reflex arc of neurones. Very simple motor responses, *made deliberately,* require longer time. For example, in making a series of taps at maximum speed with the finger, intervals of at least a tenth of a second separate the reactions. By utilizing a similar muscular response, that required to jerk the finger from a telegraph key, it has been possible, by means of delicate clocks, to measure the reaction time for different types of stimuli. The interval between the reaction and a touch stimulus varies from about 110 to 160 thousandths of a second; the same reaction to a sound stimulus requires from .120 to .170 second; to cold .150 to .200; to light .150 to .200; to warmth .180 to .230; to odors .150 to .200; to taste .300 to a full second; to pain .400 to a second.

Factors Which Influence Reaction Time.—The differences in time between some of the reflexes and others, and between reflexes in general and the voluntary or acquired reactions, as in the examples just mentioned, must be due in part to the differences in the pathways followed by the nerve impulse, since the same kind of stimulus—say a sharp touch—may be used in all. Differences in the pathway may be due to the directness of the connections, whether the first, second or third level is

involved, and to differences in the openness of the synapses encountered. In the experiments in which the same finger muscles were used and other conditions, so far as possible, were made identical, except the kind of sense organ stimulated, there appears evidence that different amounts of time are required for a stimulus to arouse nerve impulses in the receptors. The receptors for touch and sound are quick; those for taste and pain are slow.

Other factors affect not only the time but particularly the force or vigor of the reaction. The strength of the stimulus is one such factor. A strong pin prick, electric shock or sound will cause a more pronounced and quicker reaction than a less intense stimulus of the same kind. The existing condition in the reaction mechanism and perhaps also in the connecting and receiving mechanisms, also affects the time and vigor of the reaction. Fatigue in the sense organ and muscle have considerable effect; fatigue in the connecting mechanisms possibly but not certainly, some effect. Decidedly potent is the condition usually termed the "readiness" or "set." When the runner is "set" on his mark; the benighted boy, strained with fear, or the subject of an experiment "ready" to jerk his finger from the key, the response to the expected stimulus is usually more rapid and pronounced than when the person is unready. Readiness in these instances involves at least a partial activity, a high level of tonus, in the muscles. It may involve more, a condition of readiness of some sort in the connecting mechanisms, probably at the synapses. While its exact nature is not well understood, the condition of readiness—which we shall meet again in discussing other types of reaction—is an important factor in conditioning activity.

Even small differences in the strength of the stimulus, in the condition of readiness, and in other conditions like

fatigue appreciably influence reactions of the simplest character. Differences in these factors produce such considerable variations in response, that to secure a representative measure of the simplest reaction time of an individual, it becomes necessary not only to arrange the experiment with great care but also to secure many measures from which the average is computed.

Structure of Smooth Muscles.—The *smooth muscles* are found chiefly in the walls of the gullet, stomach, the small and large intestines, in the genital and urinary organs, the bronchi and diaphragm, in the walls of veins and arteries, attached to hairs, and in various glands. In structure the smooth muscles differ considerably from the striped; instead of threads the elements are tapering spindles which unite to form a tissue, such as the wall of the stomach.

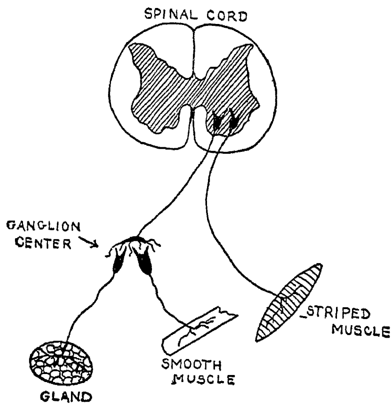


Fig. 21.—On the Right is Shown the Motor Neurone Running Directly to the Striped Muscle; on the Left a Motor Neurone Terminating in a Ganglion Center from Which Neurones of the *Autonomic System* Continue to the Gland and the Smooth Muscle.

Smooth Muscles Connected with the Autonomic Nerves.—The smooth muscle spindles are supplied by neurones that are somewhat different from those which supply the striped muscles. We need not be concerned with the minute differences, and need only note that certain motor neurones from the spinal cord lead to "ganglia" (*i.e.*, groups of neural connections outside of

the spinal cord) where they are connected by means of synapses with other neurones which run on to the smooth muscles. The neurones connecting the ganglia and the smooth muscles form part of what is called the *autonomic nervous system.* In Figure 21 is illustrated the extra *autonomic* link between the motor nerve and the muscle. Instead of one neurone running from the cord to the muscle there are two or more linked by synapses. They serve the same general purpose as the motor neurone, namely, to conduct the nerve impulse to the organs of response.

Smooth Muscle Reactions.—The activity of the smooth muscles is like that of the striped muscles except that it is slower. Smooth muscles are sluggish in reaching the maximum of a contraction and slow in relaxing. They will maintain different degrees of tonus for very long periods of time. Most smooth muscles are very susceptible to the stimulating or inhibiting effect of certain chemicals, many varieties of which, developed in the body by glands, reach the "ganglia" as well as the muscle through the circulating blood. The paralysis of the smooth muscles controlling the iris of the eye by applying atropine to the surface or injecting it into the circulation is probably the most familiar example of such effects.

The Glands.

Until recently, study of the glandular mechanisms has been pursued rather exclusively by those interested in digestion and assimilation of food, in storage of reserves such as fat, in growth and in the elimination of wastes. Recent research, although not as yet extensive, has shown that the glandular mechanisms play an important rôle in general behavior.

Duct Glands.—There are two general types of glands, the *duct* glands and the *ductless* glands. The most familiar *duct* glands are the tear glands, the sweat glands of the skin, the salivary glands in the mouth, the digestive glands in the stomach, intestinal canals, liver and kidney. Each of these, by means of a duct or tube, pours its secretion on the surface of the body or into some body cavity. So far as is known, all of the duct glands are innervated by neurones of the autonomic system as are the smooth muscles.

The duct glands, so long as they are functioning normally, have little specific effect on behavior. We are rarely conscious of their operations and the secretions have effects mainly limited to such purposes as regulating temperature, softening the skin, promoting digestive assimilation, etc. When the functions of these glands are disturbed, they may have pronounced and widespread effects. Thus if a liver secretion, bile, is miscarried as in jaundice, the patient not only becomes yellow cutaneously but, what is more important psychologically, he tends to become blue mentally.

While not normally influencing general behavior the actions of the duct glands are greatly affected by our other activities. That violent or prolonged muscular activity, and especially observations and thoughts that tend to provoke emotions, have pronounced effects on tear, sweat and digestive glands is often obvious in everyday life and will receive fuller consideration later.

The Ductless Glands in General.—The *ductless* glands are sometimes called the *endocrine glands* or the *glands of internal secretion.* They differ from the duct glands in that they have no external outlet. They produce complex chemical compounds which are absorbed by the blood filtering through them and thus are carried throughout

the body. The endocrine glands, like smooth muscles and duct glands, are innervated by means of neurones in the autonomic system. We can give but a brief and fragmentary description of a few of the internal glands and their influences on behavior.

The Thyroid Gland.—The thyroid gland consists of two maroon colored masses connected by a strip of tissue on each side of the windpipe, close to the larynx. Everyone knows the position of this gland because of its great enlargement in the disease, goitre. The most important secretion of the thyroid is *thyroxin,* of which the most potent element is iodine.

When the thyroid becomes over-active, or when thyroxin is injected into the circulation or taken into the stomach, the effects, while slow in appearing, are very pronounced. The organism speeds up, is excitable and over-reacts. The pulse becomes rapid, the temperature goes above normal, and the skin is flushed and moist from perspiration. The individual is alert, irritable, unable to relax or sleep perfectly. Emotions, as fear, anger or excitable joy, are easily aroused. If the over-supply of thyroxin is continued, the individual loses weight no matter how much he eats; certain vital chemical activities (metabolism) go on at such a pace that they exhaust the reserve stores of the body.

All of these effects are symptoms of the disease, *exophthalmic goitre,* which is associated with hyperthyroidism, that is, too much thyroid. Another disease, *myxœdema,* is a chronic condition of hypothyroidism, that is, insufficient thyroid secretion. In this disorder, the symptoms are quite the reverse. All of the vital activities slow up; bodily movements are slow and clumsy; the temperament becomes sluggish, indifferent, insensitive, dull.

The Parathyroid Glands.—The parathyroids are four in number, about the size and shape of grains of wheat, located two on each side of the windpipe and imbedded in the thyroids. The secretion of these glands has not been isolated and its specific effect is not very well known. When they are removed in experiments upon animals, the subject becomes extraordinarily excitable. At the slightest sound or touch it will jump or even be thrown into convulsions. Certain human beings suffering from extreme depression, nervousness, restlessness, insomnia, and tremors, have been found to have defective or diseased parathyroids. At the present time it is believed that these glands have an important rôle in the regulation of the assimilation of lime, which in addition to being an essential element of the bones, teeth, and blood, is required for the health of nerves. Removal, disease, or insufficiency of the parathyroids, by eliminating or decreasing the intake of lime, and perhaps in other ways, produces marked disturbances of behavior.

The Pituitary Gland.—The pituitary gland, a small organ about the size of a pea, is situated in a well protected position at the base of the brain. It is really a double organ giving two secretions, each bringing about a variety of effects. Over-activity of one of the pituitary secretions causes an abnormal growth of the skeleton. The giants which we see at the circus are probably victims of an over-active pituitary function. Insufficient secretion of one or both parts of the pituitary is said to be the cause of retardation of bodily growth in the case of certain types of dwarfs.

The pituitary secretions influence the tone of smooth muscles and the activity of various functions concerned in the transformation of materials into form available for bodily work. For example, the glycogen in the liver is

more rapidly converted into blood sugar—the material burned in muscular action—when the pituitary is active. The pituitary functions appear to be influential in determining fatigability; inability to sustain effort being one of the frequent complaints of those whose pituitary secretions are insufficient.

The Adrenal Glands.—The adrenal glands, concerning which greater detail will be given in the chapter on the emotions, pours into the blood a fluid which profoundly affects nearly all of the other glands, both duct and ductless, the action of the lungs, heart and intestines, of the skeletal muscles and possibly the nervous system itself. The action of these glands is one of the most conspicuous examples of one reaction influencing others. The effect on conscious activity is as marked as on muscles and other glands.

The Glands in General.—Glandular activities, especially those of the endocrines, are markedly influential in determining bodily responses and conscious life. Especially important is their relation to the emotions, such as fear, anger, and joy; to temperamental and volitional traits such as excitability, vivacity, energy and ambitiousness; and even on the mental processes of thinking and reasoning, they may exert a considerable influence.

Exact knowledge of the functions of the glands is, unfortunately, limited. They form a complex system. A change in the amount of the secretion of one affects many or all of the others. In what little is known it is apparent that the system of reciprocal innervations, involving both facilitation and inhibition, which was observed in the case of muscles, has a parallel among the glands. The secretions of the adrenal and thyroid have certain common functions as well as some different, almost antagonistic ones. The influence of adrenal secretion on the liver's

control of sugar is quite the reverse of the effect of secretions from the pancreas. The influence of secretions on muscular activities likewise may be either to increase or inhibit action. The thyroid secretion tends to increase the contractions of certain smooth muscles in the intestines whereas adrenal secretion tends to reduce or inhibit them. The action of the same gland, moreover, may be differential; adrenal secretion inhibits movements of the stomach but increases the activity of the heart.

Glandular reaction, then, presents a vivid illustration of activity leading to further activity. Although the mode of operation is different, the internal secretions bring about many reactions that are much like those produced by direct stimulation of distant receptors. A painful stimulation of almost any part of the body will result usually in an increase in heart and lung action. By means of neural connection between receptors and these reacting organs, an increase in adrenal secretion in the blood will produce an identical result. The secretions are particularly potent in prolonging altered activities inasmuch as they remain effective for considerable periods of time. The persistence of internal disturbances such as a rapid pulse and breathing following a shock or exciting experience is usually due to glandular secretions produced by these events. By influencing bodily mechanisms and internal conditions, the glands affect conscious reactions. Intimately related to excitability and calm, fatigue and vigor, elation and depression, anger and fear, impulsiveness and poise, the internal secretions play an important rôle in general behavior that psychology must not neglect.

THE CEREBRAL CORTEX AND ITS FUNCTIONS

A description of muscular and glandular activities does not exhaust the forms of behavior that constitute our everyday experience. Most of us would rate high, in terms of importance, our sensations, thoughts and feelings, that is, our conscious or mental experiences. There are three problems before us in seeking an understanding of mental activity:

(1) Upon what bodily organs do our states of consciousness, sensations, images, memories, etc., depend.

(2) What are the characteristics and varieties of mental states?

(3) What are their functions—how do they influence behavior in general?

In the present chapter, attention will be limited mainly to the first of these problems.

The Physical Basis of Consciousness.—We must admit at the outset that if we stand by scientific evidence, we cannot say with certainty that the activity of any organ produces a sensation or some other state of consciousness in the same manner that a muscle produces a movement or a gland produces a secretion. All that we can say is that the activity of certain organs seems to be a necessary condition of conscious experience. These organs are certain neurones located mainly or wholly in the cortex or outer layer of the brain. The assumption is that the nerve impulse, initiated at the sense organ, is relayed through the cord and the mid-brain by axons leading to the sensory area in the cortex of the brain. When these cortical neurones are thrown into action by the nerve impulse, we have the condition under which consciousness occurs. The cortex seems to be the imme-

diate physical basis, or, if you wish, the organ of consciousness.

Several lines of evidence favor the hypothesis that activity of the neurones in the cortex of the brain is the basis of conscious experience. The fact that a blow on the head or the stoppage of the flow of blood to the brain results in loss of consciousness is suggestive but not conclusive evidence. More convincing proof has been secured by observation of the effects of *partial* loss or destruction of the cortex by injuries, operations or disease. The removal of certain areas of the cortex invariably results in the loss of certain kinds of consciousness. The removal of one area results in the loss of visual sensations—the individual is unable to see even when the eye and the sensory nerves are unimpaired. When another area is removed, the individual is unable to become aware of (conscious of) sounds although the ear and the sensory neurones are uninjured. The destruction of other areas abolishes sensations of pain, cold, hot, pressure, taste or smell. Widespread cortical removal results in losses of images, memories and other conscious experiences even though all other bodily organs—the sense organs, the cord and mid-brain, motor nerves, muscles and glands—are left intact.

Science is unable to explain the relation between activity of the cortex and consciousness. The immediate stimulus is the nerve impulse. When it traverses certain cortical neurones, a sensation or some other conscious experience occurs, but just how or why is quite unknown. The circumstances, to use a rough analogy, are similar to those attending the production of light in an electric bulb. The electric current flows along the wire with no observable effect but, when it reaches the filament of the light bulb, there results a brilliant glare. No one knows,

as a matter of fact, what electricity is nor precisely why it should, when circulating through the filament, produce light, rather than a sound, an odor or some other result. Of course, a certain number of facts are known concerning the properties and effects of the electric current, which provides an approximation to the explanation of the occurrence of light, but the explanation is not complete or ultimate. Less is known concerning the properties of nerve impulses and their effects on the neurones of the cortex, but the evidence nevertheless is such that we may assume that nerve impulses flowing through certain neurones are the necessary conditions of consciousness even if a complete or ultimate explanation of how or why is not available.

Localization of Conscious Functions.

To some extent, the particular areas of the brain whose neurones are most intimately concerned with definite conscious states are known, and study of them assists somewhat in classifying and understanding conscious behavior.

Main Features of the Cortex.—The brain comprises the *cerebral hemispheres,* or the two *cerebra* (the singular term is *cerebrum*). The cerebra include the whole content of the skull except the mid-brain with its appendages. The dividing line between the cerebra is a deep central cleft. In general size and appearance, the cerebra differ from man to man about as faces do; the main features can easily be made out but minor differences are always found. Figure 22 gives pictures of the surface. The neurologists have the brain surface very carefully divided up, like a map, into various areas, using many of the depressions as boundary lines. There are four large areas: the Frontal Lobe in the forehead, the Temporal

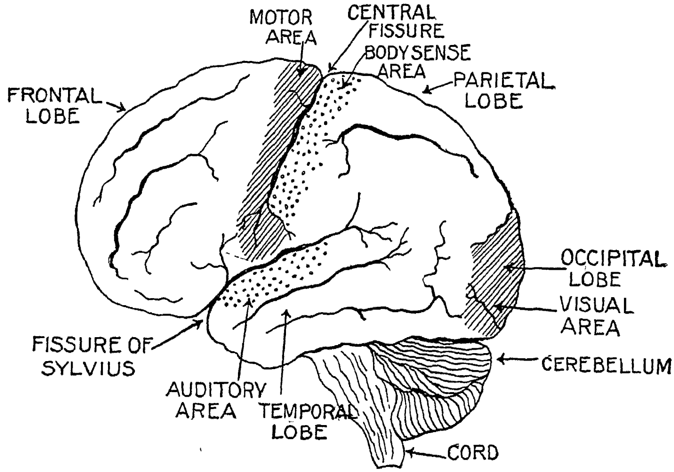


FIG. 22—SIDE VIEW OF THE LEFT HEMISPHERE OF THE BRAIN SHOWING THE IMPORTANT FISSURES AND LOBES AND THE PRIMARY VISUAL, AUDITORY AND BODY SENSE AREAS.

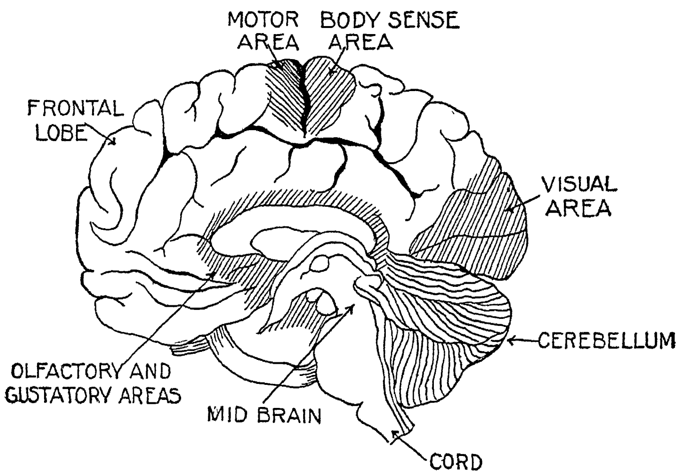


FIG. 23.—THE INNER SURFACE OF THE RIGHT HEMISPHERE SHOWING PARTS CONCEALED IN FIGURE 22. The olfactory and gustatory areas are also shown.

Lobe at each temple, the Occipital Lobe at the back and the Parietal Lobe on top; and two fissures, the Central Fissure which divides the front from the hind part, and the Fissure of Sylvius which begins at the temple and, running toward the rear, marks off the Temporal Lobe which lies below.

The nerve impulses initiated in the sense organs in various parts of the body are relayed by central neurones until they arrive at what may be called the *primary sensory areas* in the cortex. The primary sensory areas connected with the important sense organs are fairly definitely known. The impulses coming in from the eye are relayed to the portion of the cortex in the posterior part of the brain, *i.e.*, in the Occipital Lobe. This area may be called the *primary visual area.* No other part of the cortex receives nerve impulses directly from the visual receptors. The impulses from the ear are conducted by chains of neurones to the area of the cortex in the Temporal Lobe. This may be called the *primary auditory area.* The organs of taste are connected with the *primary gustatory or taste area* which is near the bottom of the cleft between the two cerebra. In the same region is the *primary olfactory area* which receives the impulses from the sense organs of smell. The sense organs of the skin and, to some extent, those of the muscles, ligaments and joints, send impulses which reach the cortex in a narrow area which runs from the top of the brain down the posterior side of the Central Fissure, ending at the Fissure of Sylvius. This strip may be called the *primary bodily-sense area.* The primary cortical areas of other sense organs—such as those of the semi-circular canal and of many internal organs—are not known.

There are two important facts which we should know concerning the several primary sensory areas:

(1) They contain the neurones whose activity is primarily and essentially correlated with the conscious response, the *sensation.*

(2) They are profusely connected, by neurones both in and under the cortex, with many other parts of the brain.

The Effects of Removal of Parts of the Cortex.—The evidence that the primary sensory area of the cortex is essential to sensation is twofold. Destruction of this area results in the loss of sensations, whereas injury of other areas, such as those immediately surrounding the primary centers, does not eliminate sensations. Destruction of the total primary visual area results in blindness; destruction of part of the area results in partial blindness. Whenever this area is wholly or partly removed the result is a loss of visual sensations, in whole or part. When the primary visual area is uninjured but the area surrounding it is destroyed, the result is not blindness, but inability to recognize or comprehend the object which provides the visual stimulus. The subject is aware of (conscious of) a patch of color of a certain size but he cannot recognize it as an orange; he *has no idea* what the stimulating object is. One patient called a clothes-brush a pair of spectacles, an umbrella a plant with flowers, an apple a portrait of a lady. Complete destruction of the outlying parts would result also in "word blindness," a condition in which the subject really *sees* (is conscious of) the word, but cannot interpret it. The symbol has no more meaning than a Chinese character to an American child. The patient might also be unable to recognize his friends, his house, and other objects, although seeing them. The visual stimulus arouses but one conscious response, the sensation. No other conscious reactions—percepts, images, memories, thoughts—occur.

Removal of the cortex surrounding the primary audi-

tory area results in similar losses of conscious reactions. The subject is aware of sounds but unable to interpret or comprehend them, unable to tell whether they are sounds of the human voice, a piano or a passing automobile. Removal of small portions of the surrounding areas may result in inability to recognize tunes, or to understand spoken words, or in some other limited loss of compre-

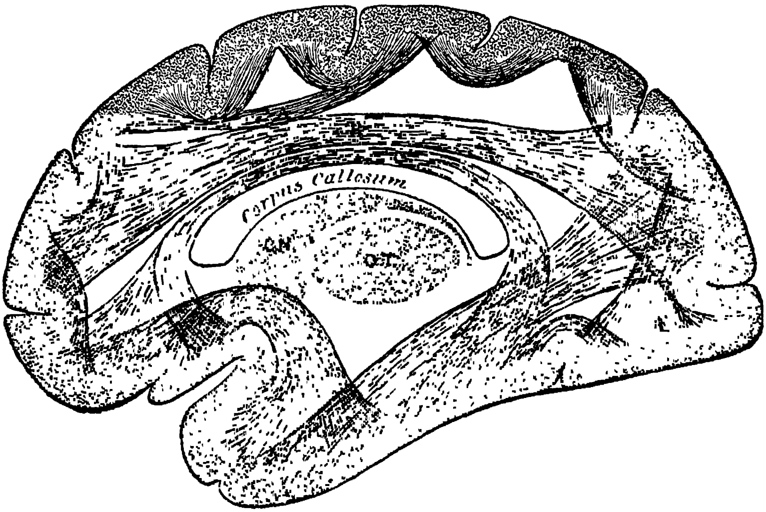


Fig. 24.—Bundles of Neurones Connecting the Various Parts of the Brain. The part marked *Corpus Callosum* represents huge bundles of neurones interconnecting the two hemispheres. (From Starr.)

hension without any defect of the primary capacity to hear sounds.

Removal of the regions surrounding other primary sensory areas results in similar disturbances. The patient may be able to smell, taste, feel with the hand, but no conscious reactions beyond the bare sensation are experienced.

Sensations.—Sensations consequently must be a particular kind of conscious reaction distinguishable from

other mental activities which constitutes recognition or perception of objects, recollection of, or ideas about objects. Sensations appear to be the first conscious reactions occasioned by external stimulation, since they have as their "seat" the areas first reached by the incoming nerve impulse. It is important to realize that they are reactions —to see, hear, taste, smell, or experience hot, cold, pressure or pain is to react to a stimulus. Sensations do not occur spontaneously without a cause. They are not things or processes within us which are brought into prominence by some type of self-activity or by some mysterious power of the "mind." They are, like movements, the results of activity occasioned by definite stimuli.

Other Conscious Reactions.—The sensation is the first conscious reaction, shortly followed by others. Each primary sensory area is profusely connected with other parts of the brain, thus making it possible for nerve impulses to be switched off in almost any particular direction, to reach almost any other region of the cortex, or to be distributed at once along many different routes. It is probable that removal of the areas surrounding the primary sensory centers cuts off all or most of these connections with other parts of the brain, thus eliminating all reactions, conscious or otherwise, which are dependent on more remote brain areas. The cases just mentioned, in which removal of the region immediately surrounding the primary sensory area resulted in the elimination of recognition or perception of the stimulating object, do not necessarily prove that the area removed was the only one involved in comprehension. The pathways which run through these areas are essential but not necessarily sufficient. To destroy them may result merely in cutting some of the links in a continuous chain of neurones, all

of which may be involved in a complex mental response.

The localizations of the conscious activities that follow sensations might be determined by starting at some remote area, removing portion after portion, working in the direction of the primary sensory areas, determining after the removal of each part, what conscious reactions remained and what ones were abolished. This type of investigation, to be of value, would have to utilize human subjects, an enterprise which is obviously impossible. Such data as are available have been secured by studies of individuals who have lost portions of the brain as the result of surgical operations, accident, or disease. Such cases have been too few in number and too varied in kind to yield very significant evidence, but they indicate, for such conscious reactions as percepts, recognitions, memories, imaginations and ideas, dependence not upon sharply defined areas but upon tracts penetrating variously all parts of the brain.

The Complexity of Brain Action During Thinking.— The probable complexity and extensity of brain activity may be illustrated by an adult's reactions to the printed word *apple*. The stimulus, a group of light waves, strikes the retina of the eye, activating a nerve impulse which, on reaching the primary visual area, arouses certain neurones whose activity is somehow correlated with a sensation. The individual then sees a series of little black marks on a white ground. The sensation is merely this awareness of black and white. But almost instantly, at an interval too brief to be appreciated, the subject comprehends, or is aware of, the meaning of the word. He at once thinks of *appleness,* which means probably a fleeting consciousness of a round, colored, hard, odorous, edible object. Probably this really complex consciousness involves certain neurones running off toward the

olfactory area, others toward the gustatory area, others toward the skin or body sense area, and others to intermediate regions. The perception of the word would thus involve an extensive, complex pattern of neurones. Each percept involves neurones in many brain areas. Different percepts depend upon the same general areas, but the patterns of particular neurones concerned are as numerous as the percepts themselves.

The act of perception is usually prompt. It is the almost instantaneous awareness of recognition of the stimulating object or event. In the present illustration, on seeing the word *apple,* one at once becomes aware of its significance, and the percept may be promptly followed by a series of thoughts or ideas. One may think of the kind of tree on which the fruit grows, of the appearance and number of such trees in an orchard familiar to childhood, and then of related childhood events. The percept leads to an idea, which leads to another idea, and so on. The whole series may in one case constitute a reverie, in another, imagination, and in another, purposeful thinking. In any case, the continuity, despite the rapidity with which thoughts succeed each other, is the significant matter for which a neural basis should be suggested.

Each thought in the series is paralleled by the activity of a complex pattern of cortical neurones which is not sharply localized, but widespread. The activity of one group of neurones, itself a reaction, leads to activity of another group, and so on. Thus each brain reaction becomes the stimulus which activates another brain reaction in somewhat the same manner as, in writing, the muscular acts made in one moment become the stimuli which occasion the acts of the next moment. And just as the series of acts in writing constitute a complex, rapid

and apparently smooth continuity, so a train of associated ideas seems more like a flowing stream than like a series of distinct reactions. Actually, however, the stream of thought corresponds to a series of neural reactions, each caused by another preceding reaction, one following another with great rapidity.

One conscious reaction may lead to another associated conscious reaction, but this is not all. A conscious response may lead to muscular and glandular reactions as well. It is typical of the human individual to act after having perceived the situation or after having thought about the situation perceived. Conscious activity is the antecedent of much of human activity, a fact that will appear more clearly after a consideration of the motor area of the brain and its relation to the areas primarily involved in conscious life.

Localization of Motor Functions.

The Frontal Lobe of the brain, which occupies the whole region in front of the Central Fissure and above the Fissure of Sylvius, is mainly motor in function in the sense that therein are the neurones most immediately concerned in directing nerve impulses downward through the mid-brain and spinal cord to issue into muscles and glands. In a long narrow strip of cortex immediately in front of the Central Fissure, running from the top downward to either temple, are contained the ends of the motor neurones which lead to the organs of response. This area, which we may call the motor area, is comparable in certain respects with the primary sensory areas. The latter are the regions to which all incoming neurones lead; the former is the area from which practically all outgoing neurones issue. Destruction of the primary sensory areas eliminates consciousness and all action

which follows it, whereas destruction of the motor area leaves consciousness intact but eliminates the motor response. Thus, destruction of the motor area would render the patient incapable of speaking a word which he can see and recognize, of running his typewriter, of handling properly a knife and fork, of catching a football, and of writing, even when he is capable of perceiving and thinking about these objects and the situations in which they are encountered. Complete destruction of the motor area, by cutting off the motor connections between the brain and the organs of response, would eliminate acquired acts and what is usually called voluntary action, by which is meant responses whose immediate antecedent is conscious activity.

Destruction of the motor area does not result in complete paralysis, since the reactions of the spinal level, the reflexes, and those of the mid-brain level, the more complex unlearned reactions, can still be made when proper stimuli are provided. The individual can vocalize, chew, swallow, walk, jerk away from pricks and burns, but he cannot speak English, sing an old song, handle machines and perform other learned or voluntary acts.

Localization in the motor area, as in the primary sensory areas, is more exact than in the intermediate areas. The top portion of the brain area is connected with the muscles in the lower limbs, the bottom portion with muscles of the upper limbs and head and throughout, the brain areas and the connected body parts are in reverse order. Removal of parts of the motor area results in loss of voluntary activity in the corresponding parts of the body.

The fact that removal of the motor area results in the loss of voluntary activity does not prove that all learned

movements are located in this region, any more than the fact that removal of the primary sensory area, which eliminates all more elaborate consciousness, proves that all conscious reactions are located in the primary area. In both cases, what happens is that the connections with other parts of the brain are severed, so that activities depending on neighboring or remote brain regions are cut off.

Connections of Motor and Sensory Areas.—The motor area occupies but a small part of the Frontal Lobe. All of the portion in front is richly connected with the sensory areas and the other posterior portions of the cortex assumed to be involved in conscious life, as well as with the motor area. Impulses come in at the primary sensory areas, are distributed through the posterior lobes, then over to the Frontal Lobe, and finally, by way of the motor area, are discharged into the organs of response. During the transition, conscious states, sensations, percepts and ideas may arise and, in completing the circuit, the brain is engaged much as a whole. All parts are essential to successful activity, a fact which may be illustrated by indicating the neural connections involved in human speech.

Suppose we ask an individual to repeat after us the sentence "Where is my hat?" If the primary auditory area were destroyed, he could not repeat the sentence because he would be unable to hear it. If this area were intact, but the surrounding areas removed, he would hear the words, but they would be a meaningless jargon of sound and consequently it would be impossible to repeat the sentence. If all of the sensory and surrounding areas were unimpaired, the subject could hear and understand the spoken words and also think of them but still be unable to say them when certain parts of the Frontal Lobe

in front of the final motor area were destroyed. In such cases the subject may know well enough what words he wants to say but he is unable to pronounce them. He is not wholly incapable of speech and can hear what he himself says, but it is impossible to get the right words out. The patient is not dumb but gets his words mixed up; he talks a jargon. The fore part of the Frontal Lobe is apparently concerned with the combination and coördination of movements which compose our complex learned or voluntary acts. Finally, suppose that the whole brain is intact except the final motor area. In this case the individual may hear the words and think of exactly what he wishes to say, and in addition to this, the impulses may be properly coördinated in the fore part of the Frontal Lobe, but he is unable to speak voluntarily at all. The connections leading from the motor area to the vocal organs have been cut, with the result that all learned or voluntary action is abolished. The individual's speech organs are not paralyzed, inasmuch as the mid-brain and spinal reactions may be made. The individual may cry out when frightened or injured, but the complicated acquired forms of speech are eliminated.

Analogous difficulties in the execution of other types of complex reactions may be caused by brain defects. In a disorder called "motor apraxia," the patient, because of destruction of the Frontal Lobe in front of the final motor area for the hands and arms, may recognize the object and think about it, but he cannot get the proper organization of movements to handle it. When the final motor area itself is injured, he can recognize the object and *intend* the right movements of manipulation, but they do not occur. Disturbances earlier in the chain of events, in the region surrounding the primary sensory area, make recognition and hence proper movement impossible.

Destruction of the sensory area results in total inability to see the object.

Thus there are four steps in the transition of nerve impulses through the brain: first, sensation, which means reaction of the primary sensory area; next, perception and thought, which mean activity of widely spread areas which compose the greater part of the posterior cortex; third, the organization of and preparation for a complex motor response, which involves the larger portion of the Frontal Lobe; and finally, the collection of the nerve impulses in the final motor area, where they are discharged by way of the mid-brain and cord to the organs of response. Defects anywhere along the line will occasion disturbances or disability.

There is often a very perceptible delay between perception and final movement, a delay caused by a train of thought. For instance, if a subject is asked to "Give the best synonym for the word *eloquent*," he may promptly perceive the words and grasp the meaning of the request, but he may need to think some time before deciding what motor reaction to make. Having finally decided what to respond, the movement pattern is organized and action results. Again, one may perceive that a gateway is closed and proceed to think things over for a time before deciding upon and taking a line of action. In these cases perception is followed by thinking, for a period long or short, out of which action may eventually issue.

Localization of Other Functions and Processes.

In all of these illustrations, both the intimate relation of conscious states with movement and the complexity of brain activity are apparent. In what appear to be rather simple matters, such as reading or repeating a few words, all parts of the brain are involved. Such functions, and

similarly most of thousands of other acquired abilities, are not localized in any one small area. We know rather definitely where the nerve impulses come into and where they leave the cortex, but between entrance and exit, where conscious states arise and where the complex patterns of discharge are organized, the complexity of neurones concerned is baffling.

If there is little likelihood of definite brain localizations for percepts, images, memories, ideas, emotions and other complex conscious processes, there is still less possibility of precise localization of such complex traits as executive, selling, or teaching ability, the doctrines of the Phrenologists notwithstanding. Mental traits such as sagacity, attentiveness, and intuitiveness have no compact localization, nor have temperamental and character traits, such as vivacity, cheerfulness, trustworthiness, honesty, sensitivity, or tendencies to love babies, seek power, or enjoy music. Many parts of the brain are engaged in most of the single reactions of thought, skill, or sensibility.

Conclusions.

To the muscles and glands, we may now add another group of reacting mechanisms, the cortical neurones whose activity is somehow responsible for consciousness. Conscious action is always reaction; it is the result of a stimulus, which, acting on a sense organ, activates a nerve impulse which reaches and activates the cortex or of a nerve impulse received from and resulting from the activity of, other neurones in the cortex. Consciousness may thus be the reaction to a stimulus affecting external sense organs, such as eye or ear, internal sense organs, as in the stomach or arteries, or to stimuli received directly from neurones whose activity produces other conscious states.

Stated in different terms, external stimuli, inner conditions, and the activities of muscle, gland, or cortical neurones may occasion a conscious response. At the same time, conscious activity may lead to motor reactions, as when a person, thinking of a letter in his pocket, pulls it out and proceeds to a mail box; to glandular reactions, as when the thought of candy makes the mouth water or the thought of an insult stirs the adrenal to action; and to other conscious reactions as when the thought of a vexing problem leads to further thinking. Thus all of the cycles of behavior are complete. Diverse types of activities, conceived as reactions to stimuli, one activity influenced by and leading to others, are the fundamental characteristics of human behavior.

QUESTIONS AND EXERCISES

1. Draw a diagram of both the reflex arc and the reflex circuit. Indicate the differences.
2. Draw rough sketches indicating the positions of the four main Lobes, the primary sensory and motor areas.
3. If the whole cortex of a man were destroyed—assuming the impossibility that he would live—what behavior would be lost, what would remain? (Consult references for experiments on animals.)
4. Give three differences between the phrenological conception of brain localization and the conception presented in the text. Discuss critically the arguments of the phrenologists in the light of the methods of scientific study.
5. Describe the distinctions between the *sensations* and the *percepts* in the case of hearing an auto horn, smelling coffee, tasting lemonade, fingering a coin.
6. If a man should go blind at the age of 30 due to destruction of the optic nerves, would he be unable to recall or think of past visual experiences such as landscapes, faces, etc ? If so, or if not so, explain in terms of neural connections in the brain.
7. How could investigators have discovered the existence of the sensory and other brain areas? Would the introspective method

necessarily be utilized? If so, by whom, investigator or subject? How could the brain areas be identified in animals?

8. How could one ascertain the effects of adrenal secretion on (a) excitability, (b) mood, (c) fatigability, (d) heart rate, and (e) ambitiousness? Would the introspective method necessarily be used?
9. What differences or distinctions can you find between muscular and glandular responses on the one hand, and cortical reactions (consciousness) on the other? Are any of these distinctions necessarily antagonistic to the idea that conscious activities are reactions?
10. Why is so much less known about the architecture and functions of parts of the brain than is known about the spinal cord?

GENERAL REFERENCES

For further details concerning muscular activity, see a physiology, such as W. H. Howell's *A Textbook in Physiology,* Philadelphia: W. B. Saunders; for facts concerning reaction time, see G. T. Ladd and R. S. Woodworth, *Elements of Physiological Psychology:* New York: Scribner's, 1911.

For non-technical accounts of the glandular mechanisms see B. Harrow, *Glands in Health and Disease,* New York: Dutton, 1922. A colorful but highly speculative and imaginative account of glandular activities may be found in L. Berman, *Glands Regulating Personality,* New York: Macmillan, 1921.

The references at the end of Chapter III include discussions of brain localization. To these should be added an article by S. I. Franz entitled, "Cerebral-Mental Relations," *Psychological Review,* March, 1921.

CHAPTER V

NATIVE EQUIPMENT: STRUCTURES, CAPACITIES AND THE THEORY OF SPECIFIC INSTINCTS

With some knowledge of the mechanisms upon which human behavior depends, and the general characteristics of muscular, glandular and conscious activity at hand, we are now in position to begin a survey of the behavior of man as a whole. To understand the conduct of the adult, we need to consider the origin and development of some of the capacities and abilities that are his. Especially it is important to secure as good a notion as possible concerning the degree to which the ability and character of the adult are the result of sheer growth of inherited capacities and to what extent they are due to the fortunes of life and to systematic cultivation enforced or self-initiated. We should, then, begin our observations of human behavior at the earliest possible moment.

If we had before us several newly-born infants for observation, it would soon be apparent that in the weight of the body, color of eyes, shape of the nose—in fact, in any anatomical feature we might single out—marked individual differences occur. In the sensitivity of the eye, ear or other sense organs, in the speed and force of muscular reaction, in the conductivity and modifiability of the nervous system, in the efficiency of heart action, in the glandular activities of digestion, and in resistance to disease, variations are apparent even at birth. How are

we to account for these differences? Are they in any way acquired before birth, due to accidental factors, to differences in nutrition or in maternal activity, or is there some other explanation of their existence?

What is known about pre-natal influences makes it appear improbable that most of the anatomical and functional differences which appear at birth are acquired. While severe illness, emotional disturbances, malnutrition, alcoholism, and other serious misfortunes of the mother may affect the child through the mother's impoverished or poisoned blood, and while the child may be directly harmed by infectious disease or by injuries before birth, these facts seem to prove merely that there is required a pre-natal environment that will permit normal growth to go on. Given favorable conditions up to the time of birth, differences among infants will still appear; differences that are not acquired before birth but inherited.

Life begins with the fertilization of the ovum, a microscopic but very complex cell. Contained in the cell are certain elements or "determiners" out of which the various bodily organs and functions develop. Certain determiners grow into certain sense organs, others become particular bones, others become teeth, and so on. Even for the most minute traits, the color of the eyes or the shape of the lobe of the ear, there exist determiners in the original cell. Except for the occasional pre-natal disturbance of the severe types mentioned, the differences among infants which appear at birth are native in the sense that they are the result of the unfolding, innate growth of determiners which existed in the germ cells from the beginning of life.

At the time of birth, however, almost no trait, not even the color of the eyes, is fixed in its final form. Growth is

still going on; the eyes rapidly become a deeper blue, the bones lengthen, the face takes on new expression. Are these changes which take place after birth, like pre-natal growth, largely an unfolding of innate traits, or are they now more largely determined by the influences, training or experiences provided by the much more variable and complex environment? As illustrations, we may consider the growth of the following human traits:

1. Anatomical traits.
2. The capacities or functions of bodily organs.
3. Types of reactions, such as grasping, sneezing, crying, fighting.

The Growth of Anatomical Traits.

The growth of height might be taken as an illustration of the development of an anatomical trait. Beginning at approximately zero height an average boy has grown to about 20.5 inches at birth, to about 42 inches at the age of five, and from that time growth increases fairly uniformly until the maximum height of about 68.5 inches is reached in his seventeenth year or thereabouts. Different individuals show various curves of growth, some less regular than others, some maturing later than others, and reaching different maximal heights, and these variations as well as the rates and limits of growth are, in the main, determined by original nature by elements which existed in the germ cells. Of course, the child will not grow as he should without proper food, sleep and exercise, and his development may be disturbed by disease, poisons and other harmful influences. But given a reasonably good environmental opportunity, the child matures in accordance with his inherited predisposition.

Other anatomical traits such as the color or size of the

eye, the profile of the face, or shape of the pelvis are, like height, determined mainly by original nature. The eye color assumes its final form very early, perhaps in the first year; the profile of the face changes slowly. The

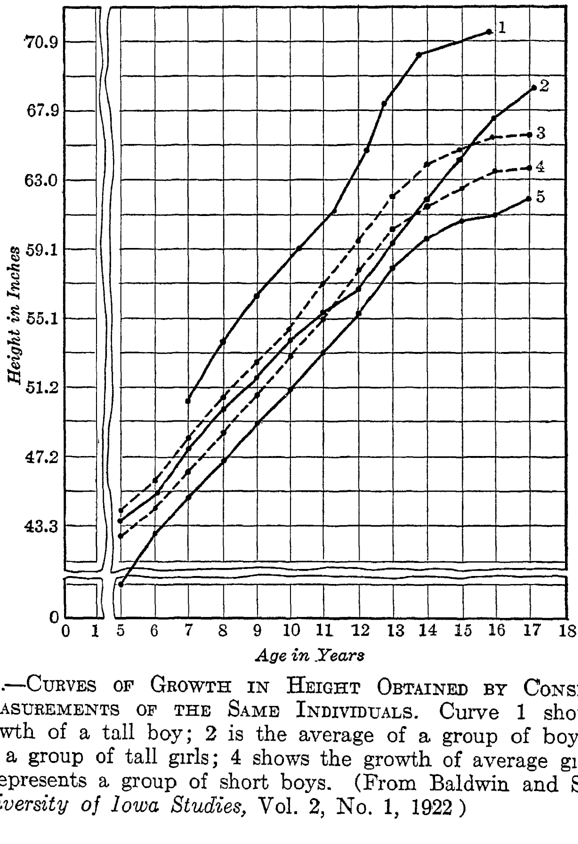


FIG. 25.—CURVES OF GROWTH IN HEIGHT OBTAINED BY CONSECUTIVE MEASUREMENTS OF THE SAME INDIVIDUALS. Curve 1 shows the growth of a tall boy; 2 is the average of a group of boys; 3 is for a group of tall girls; 4 shows the growth of average girls and 5 represents a group of short boys. (From Baldwin and Stecker, *University of Iowa Studies,* Vol. 2, No. 1, 1922)

growth of weight, while it shows a curve similar to that of height except that it is more irregular, is more susceptible to environmental factors than is the development of most anatomical traits. An afternoon of violent exercise may reduce weight somewhat, without perceptibly

affecting height. Malnutrition and most forms of illness have less effect on height than on weight. But here again, given a normal life, weight is largely an expression of native constitution; that is, if many children were given identical amounts and kinds of food, exercise, and sleep, and were free from disease, they would still attain different weights.

GROWTH OF CAPACITIES AND FUNCTIONS.

Sensitivity of the Sense Organs.—The sensitivities of the sensory mechanisms are fairly well developed at birth, although growth is rapid for two or three years thereafter. By the age of three, the organs are very nearly as sensitive to stimuli as they will ever be, although it is probable that very gradual growth occurs until a maximum is reached in the late teens. Much the same curve of development is shown by the capacity to discriminate between stimuli; for example, between high and low notes, dark and light shades of gray, heavy and light pressure. The development of such sensory capacities seems to be determined largely by inner factors rather than by experience. Diligent exercise produces at any one stage some improvement, but the limit is soon reached. If one's auditory acuity is poor, no amount of special practice will result in a high degree of acuity. People blind from birth, despite more extensive auditory experience, have, as a group, no greater sensitivity than other individuals.

In making these statements, two sources of confusion should be avoided. The one is the case of defects of the accessory apparatus of the sense organ, for example, in the lens or muscles of the eye, which may be remedied or corrected, thereby improving the function of the organ without actually changing the sensitivity of the receiving

cells. The other is the fact that practice by the blind may result in very great ability to interpret sounds which the normal individual would disregard. The blind, by attending to the echoes from their footsteps, may detect the presence of obstacles or doorways in a room, but this sort of learning does not imply an increase in sensitivity of the sense organ.

Functions of the Reacting Mechanisms.—The functions of the reacting mechanisms, like those of the receiving mechanisms, show typical rates and limits of growth. Concerning the development of the glands, very little is known. Most of them seem to be functioning actively from birth until death; for example, the thyroid, the pituitary, the adrenals, the pancreas, the salivary, sweat and lachrymal glands. The pineal and thymus appear to function actively in childhood and to die with it. The sex glands show various stages of growth with the appearance of new functions at pubescence. Extraordinary conditions, disease, shock, overwork, may disturb the functioning and growth of any of the glands but normally the development is determined from within.

The speed of muscular reaction, as determined by the number of taps made in a given time or by the time in thousandths of a second, required to jerk the hand from a telegraph key at a signal; the precision and steadiness with which a subject can move a short pointer down a continuously narrowing groove and the strength of muscular reaction represent fairly elementary muscular capacities upon which, among other things, the acquisition of skill depends. As children become older, their efficiency in all of these functions increases. That innate growth is responsible in a goodly measure for this development can be shown by an experiment. If we take a group of adults or children of the same age and give them

five minutes' daily practice in tapping, they will have reached their limit of improvement in from 12 to 22 days. But their maximal abilities are very different. These differences, since practice up to the limit of the individuals' capacities does not obliterate them, must be innate. Young children who have reached their practice level may, after an interval of time during which growth occurs, again improve somewhat by practice. The degree of absolute achievement at any stage may be increased by special practice or experience but only within certain limits which are determined by native endowment. When practice and other circumstances of life are equalized, differences between individuals will still exist and these differences are native.

Capacities of the Nervous System.—Modifiability and retentiveness of the neurones, upon which learning depends, can be measured at least roughly by tests of general intelligence or general mental ability or of the rate and permanence with which various types of information and skill may be acquired at different ages. As we shall see later, the capacity to learn and retain develops gradually from birth to maturity in a manner which resembles strikingly the course of growth for height. While we are still in doubt about the earliest and latest stages and other characteristics of the growth of these capacities, the essential fact that they do grow in a manner determined by native endowment is well established. The capacity to learn and retain, to profit by practice and experience, is native. Like other innate traits, a favorable environment is required to permit normal development which may be retarded or inhibited by extraordinary misfortunes, but so far as we know no special type of exercise or training will greatly increase these capacities. To be well fed, healthy, and normally

active, physically and mentally, is sufficient to enable these powers to attain their full fruition.

The Instinct Theory.

We have spoken of the development of certain bodily organs and traits and of certain important capacities and functions. We find in addition to these traits and capacities, and depending upon them, a wide variety of activities,—crying, breathing, grasping, creeping, walking, fighting,—going on immediately after birth or appearing at a later time. The question arises as to whether all of these activities are acquired as the result of experience and practice or whether some or all of them are, like the growth of bones or the appearance of teeth, mainly the result of inner development depending on "determiners" existing in the germ cells at the genesis of life. If forms of behavior—that is, reactions to stimuli—do result from innate development alone such activities are said to be instinctive, or to use nearly equivalent terms, innate, native, inherited, or unlearned.

Taken in the simplest form, all activity is instinctive. The mere capacity of the muscle to contract, the gland to secrete, the cortical neurones to activate consciousness is unquestionably native. Such activities are the functional correlative of structure. Always with the possession of a given organ goes at least the capacity for its use in some simple form. If this were not true the organism would forever remain inactive. The problem presented by the instinct theory, however, is *whether coördinated reactions to definite situations are native;* whether in the nervous system native connections are provided which result in some particular response, relatively simple or complex, to specific situations. It is the question whether the child creeps, walks, runs, climbs, adjusts the sense

organs, cries in fear during a thunderstorm, dodges missiles and fights in a characteristic way because his nervous system by inner development attains the connections involved in these acts or whether such responses are acquired during experience. The hypothesis that many such forms of response are native is called the *instinct theory.*

THEORETICAL BASIS OF THE INSTINCT THEORY.

The theoretical arguments in favor of the instinct theory are two; one resting on an analogy between the growth of bodily organs and capacities and the growth of behavior, the other on an analogy between animal and human behavior.

Analogy with Growth of Organs and Functions.— The first theoretical consideration is based on the assumption that the growth of neural connections, upon which instinctive behavior must depend, would most probably have the same general character as the growth of bones, skin, sensory and other organs. If the eye-color reaches its final form very shortly after birth, if the sensitivity of the sense organs reaches a limit late in the teens as the result of inner development, then, it is argued, it is reasonable to admit the possibility that types of behavior such as forms of manipulation and vocalization, abilities to manage the body as in locomotion, etc., may develop gradually and mature at some time after birth mainly as the result of innate changes in the nervous system. Again, it is argued that as the growth of the permanent teeth or of hair on the boy's lip begins, or at least develops in a spurt, considerably after birth so the appearance of certain forms of behavior such as walking, fighting or courting may be the delayed flowering of innate neural growth.

Birth, it is pointed out, is not a period of metamorphosis but merely an incident in development; growth and unfolding continue thereafter quite as before. Specific innate growth of neural connections is no less possible, theoretically, than specific development of muscles, teeth, bones or glands.

Analogy with Animal Behavior.—In addition to the argument based on analogy with the growth and delayed appearance of bodily structure, the theory seeks support in the conviction that instincts exist in animals and are therefore probably found in man. It is first assumed that many of the activities such as web-spinning, nest building, flying, mating, and stalking prey, of insects, fish, birds and beasts are instinctive. If this assumption is correct, then it is reasonable to suppose, in the light of the theory of evolution, that analogous activities in man are also instinctive. Just as there is a continuity of organs and structures, of eye, bones and brain, there may be expected a continuity of behavior. Indeed, many believe that man, the most complex of living organisms, should possess an instinctive equipment more extensive and complex than that of any other organism.

These two arguments, the one based on analogy with the growth of human physical structures and capacities, and the other on an analogy with animal behavior, are at best suggestive. Conclusive evidence concerning the innateness of patterns of behavior must be sought in other ways. How may an hereditary reaction be distinguished from an acquired one?

Means of Distinguishing Native from Acquired Reactions.

The chief means by which it is sought to distinguish instinctive from learned activities are three:

1. The test of existence at the time of birth or soon after.
2. The test of universality of appearance.
3. The test of appearance without opportunity to learn.

Reactions Appearing at Birth.—The newly born infant of the human and most other species is capable of making a considerable number of reactions at the time of, or shortly after, birth. Many of these activities such as the digestive and circulatory, some of the defensive and avoiding responses, the inner changes during anger or fright are exceedingly complicated and remarkably coördinated to serve some particular biological purpose; they are so complex as to exclude all possibility of learning under the conditions preceding their appearance. There is no way to account for them except to assume that they are the results of inner growth. The demonstration of the appearance of a complex act at birth or soon after is quite conclusive proof that it is instinctive.

Many of the reactions of man, at least those in which psychology is interested, are not obviously present at birth. They appear at various times until well in the teens. Whether any one of these activities is native or acquired must be ascertained, consequently, by other means.

The Test of Universality.—A preliminary test which has been extensively utilized in the study of the human species is based on the assumption that those traits which are universally found among human beings, present and past, civilized and primitive, whose surroundings, occupations, ideals and customs differ greatly, are likely to be instinctive rather than acquired. Especially if a trait such as walking, fear of the dark, interest in gang activi-

ties or the disposition to sing appears at about the same age and in about the same way under radically different conditions of life it would suggest that something inherent in human nature might most probably account for the facts; at least it would seem that such activities are more likely to be native than others which are not so universal. This basis of selection is known as the *test of universality*. It is not a conclusive test; merely a preliminary one. Not all universal traits need be instinctive. All peoples may eat with some form of utensil yet the child must be taught, not without difficulty, to use a spoon. Not all instinctive traits need appear universally. If hunting, killing animals or fighting were instinctive, it might not appear universally because it is tabooed by parents and society. Universality may be deceptive because some traits are everywhere taught and encouraged and others—like stealing—are in most places discouraged. The test of universality, then, must be employed with greatest care.

The Test of Appearance Without Opportunity to Learn.—In the case of a reaction which first appears some time after birth, the only conclusive proof that it is instinctive is the demonstration that it appears without education, experience or practice of any sort. Two methods of securing the information needed to satisfy this test have been utilized thus far. The first is the method of continuous observation, the other the experimental device of controlling the experiences and practice opportunities of the individual from the time of birth. These two methods may be combined in various ways.

Method of Continuous Observation.—To yield conclusive evidence, direct observation of an animal or human infant from the time of birth must be complete; not only must all of the individual's behavior be recorded

with accuracy and detail but the surroundings, activities observed by the subjects, words spoken to him, rewards and punishments given—every relevant external factor—must be noted. From such data, both reliable and complete, it would be possible to discover whether a particular reaction appeared without an opportunity to learn. If it did so appear, the activity would be accepted as instinctive.

The number of observations reported by competent persons on the human infant from birth until any considerable period later is small and none of these has approached closely the rigid control demanded for unequivocal interpretation. A number of studies by educated parents of their own infants and children and a few studies, by experts, of infants in maternity wards and orphanages which alone are available have yielded suggestive but by no means conclusive evidence. The observations of animals have been more extensive and satisfactory.

Method of Controlling the Experience and Practice of an Infant.—Experiments of this type have usually taken the form of withholding a stimulus or the opportunity to learn until a designated time whereupon the individual's first reactions may be observed. To ascertain, for example, whether children instinctively fear large beasts, the method would consist in guarding them from any experience with such animals until, at the end of the first week for one, the second week for another, and so on, the animal is presented. If the fear appeared, even long after birth without experience with, or knowledge of, beasts the likelihood is that the reaction is instinctive. In a similar way, the opportunity to attempt to walk or swim might be withheld until various delayed periods. If, at a certain time, the child is able to swim or

walk with little or no practice, the implication would be that such an act was mainly the result of inner maturity. Adequate tests of these sorts would afford very conclusive evidence. But for obvious reasons, few such experiments have been conducted upon human subjects. A number of tests have been applied to young animals.

The evidence upon which the instinct theory now rests consists of the results of a limited number of observations of human infants and animals soon after birth; a few fairly continuous, but by no means complete, studies of infants during the first few years of life; a mass of less continuous and less thoroughly controlled observations of children and adults at work and play in various places and at various times to the results of which the criterion of universality may be applied; and a limited number of experimental studies, almost exclusively upon animals, by the method of controlled opportunities. In attempting to make an inventory of the instinctive equipment of man, we shall be compelled to draw upon all available evidence which, it must be admitted, is in many instances not adequate enough to justify a positive opinion.

Evidence of Instincts in Animals.

One of the arguments in favor of the existence of numerous instincts in man is based upon the assumption that animals possess many hereditary patterns of response both simple and complex. Before such an argument could be given weight, it is necessary to demonstrate the existence of such instincts in the animals. Evidence may be sought both in the results of observations and controlled experiments. We shall offer the results of a few investigations.

Study of the Flying of Birds.—Some newly hatched birds were taken (by Spalding) and each locked up in a box so small that it was unable even to stretch its wings and isolated so that it could not observe other birds in flight. Thus these birds were deprived of all opportunity to learn until others, hatched at the same time, had become competent performers. Then the caged birds were released. They were able to fly at once, almost but not quite as well as the birds which had not been imprisoned. Their control was not quite as good; alighting for a time was clumsy, but a large part of the ability to fly had developed without specific practice.

Since the acts of flying included taking off, controlling the wings, legs, head and neck, keeping right side up, avoiding obstacles, curving down and up and complex variations of the movements of all of these organs in alighting, it is fair to describe such a performance as a complex coördinated series of responses. Since they are apparently native, the theory of instincts is well substantiated in at least one instance among animals. Other examples have also been yielded by experiment.

Study of Kittens' First Attempts to Catch Mice.—A study (by Yerkes) of the ability of kittens to catch mice took the form of providing opportunity for the exercise of the reaction before the usual time of appearance. At short intervals from birth to the end of the fourth month of their lives, kittens were placed one at a time in the presence of a mouse. At first they paid little or no attention but at a certain time, usually about the eighth week but earlier or later in some cases, the kitten quickly roused itself and launched an attack upon the mouse, an attack which according to the observer exhibited almost the complete repertoire of movements used by the adult cat in catching and killing mice. The mouse was pursued,

caught, worried, killed and partially eaten. Here, then, is a sample of rather complex behavior which appears some time after the animal has been physically capable of action. Apparently before the mouse became a stimulus to the kitten's attack-catch-kill interests and abilities, a certain neural growth had to take place. Such growth need not, of course, be as rapid and abrupt as the appearance of the reaction. Like the appearance of a blossom following steady growth of the plant, or the sudden boiling of water after a gradual heating, the reaction may be merely the flowering or culminating stage of a long period of growth.

The mouse-catching reactions and the impulses which go with it are samples of behavior which appear to be inherited in rather well organized form. Probably more exact observations would show the initial attacks to lack the precision and perfection which would result from further experience but it nevertheless appeared that a fairly effective method of response is possible with no practice at all and therefore must be considered native.

Study of Pecking by Chicks.—A better measure of the precision with which the first trials of a supposedly instinctive act are carried out is provided by an experiment (by Breed and Shepard) upon the ability of chicks to peck, seize and swallow grain. A number of chicks hatched at the same time were divided into three groups, A, B and C. The chicks in group A were first afforded an opportunity to peck grain on the second day after hatching. On this and on each succeeding day, these chicks were allowed to peck just fifty times. The chicks in group B were not allowed to peck grain until the fourth day after hatching; group C began on the sixth day. The average number of times the grains were seized and swallowed each day by the three groups are shown in

Figure 26. In all cases the performances were imperfect the first day but a high level of efficiency was soon achieved. On the whole, the increase in ability was more rapid in the groups which began later. After the seventh day, all groups, despite inequalities in previous experience, were about equally good.

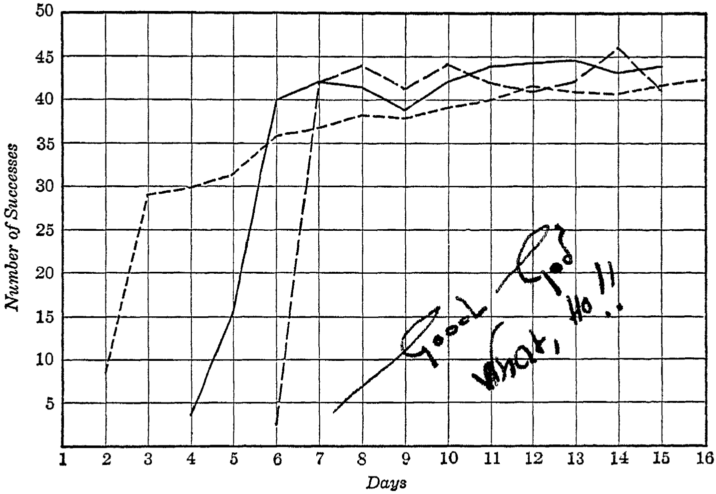


FIG. 26.—GRAPHS SHOWING THE IMPROVEMENT IN PECKING ABILITY OF CHICKS GIVEN THEIR FIRST PRACTICE ON THE SECOND, FOURTH AND SIXTH DAY, RESPECTIVELY, AFTER HATCHING. Fifty trials were given each day after the first practice. (Modified after Breed and Shepard.)

This experiment, despite the fact that practice brings about rapid improvement, illustrates the presence of an instinctive basis for the act. For one thing, pecking begins very shortly after hatching when the chick has had but a few hours of worldly experience and before bodily strength and stability is far advanced. The most significant thing is the *appearance of the impulse to peck* without guidance or example to imitate. The chick does

not just disregard, nor merely stare at, nor push with his feet nor do a number of other conceivable things with the grain but it proceeds at once to peck. At the beginning pecking it by no means totally aimless. To score a success the chick must hit the grain accurately, close his bill on it, lift it up, get it into his mouth and swallow. There are many possibilities of a miss between the ground and the crop; the first efforts are not very poor and the amount of practice leading to a high degree of perfection is very small. After a single practice period, the chicks which began on the sixth day improved but slightly from further experience.

This study illustrates, moreover, characteristics which may be found in many activities fundamentally native, namely, the relative imperfection of first attempts and the supplementary effects of practice in polishing off, in perfecting the act. Imperfection in the first attempts is by no means inconsistent with nativeness; on the contrary, it is quite to be expected, partly because maturity of neural connections is not achieved in an instant but requires time for growth even in those traits which appear early and partly because the inheritance of a motor response exactly fitted to the first situation encountered is not to be expected. What develops innately is in such cases a neural mechanism roughly fitted to the situations found in the environment.

Other Evidence from Observation.—Numerous observations of moths, wasps, bees and other insects make certain the existence of complex instincts in these organisms. The Yucca moth, for example, immediately after emerging from its chrysalis, without observation of older moths, begins to collect pollen, and having kneaded it into a pellet, flies away to another flower. Having found another Yucca flower, the moth pierces its pistil and lays

her eggs among the ovules. The bit of adhesive pollen is then stuffed into the funnel shaped opening from the top of the stigma. This series of nicely adjusted actions, each one essential to the hatching of the eggs, and the life of the grub, is done too soon and too perfectly to be accounted for by learning; it is unquestionably instinctive. The early or rapid appearance of walking, running, scratching, swimming, huddling, ruffling feathers when cold, stretching feathers to avoid sunlight, and the even more complex acts of stalking prey, gathering and hoarding food, of fighting, running away, hiding, shamming death in several species suggests strongly that many of such abilities are instinctive. The highly complex activities of courtship and mating, of building nests or other habitations, of hatching eggs and caring for the young, are believed to be in many species so complex, so universal and invariable, and so prompt to appear at the proper time as to make inheritance a far more likely explanation than learning.

While it is probable that many activities in animals are learned it is also probable that many reactions, both simple and complex, are instinctive, as flying, pecking, and catching mice appear to be. The evidence indicates also that very complex activities such as nest building and caring for the young are mainly unlearned in certain species. That very complex activities in insects are instinctive is conclusively established as the result of many careful observations.

Some students—as was mentioned earlier—are disposed to think of the human species as a close kin of the lower animals with respect to native equipment. Finding evidence that complex patterns of response are inherited by animals they are convinced that in man many complex acts are also native.

Objections to the View of Extensive Equipment of Specific Instincts in Man.

To this view there are other competent students who object. They object, first, to the argument that man has all of these varieties of instinctive equipment because they appear in animals. They do not deny the theory of evolution but assert that as the human species developed from lower mammalian forms native equipment ran less extensively to specific instinctive activities and more to intelligence and the capacity to learn. Man, they maintain, differs from the lower animals by possessing greater aptitude for learning, for profiting by experience and a relatively long period of infancy in which to acquire adaptations to his surrounding. He differs from the lower organisms, secondly, by possessing fewer ready-made adjustments, fewer specific instincts. More than other animals, it is urged, man is left to mold his behavior according to the situations and needs encountered; more than other organisms he is freed from the blind impulses of inherited specific reactions.

These students object, secondly, to universality as a suggestive test of nativeness. They point out that environment and life everywhere have a great deal in common and that what are often called instincts are really habits universal in range. For example, walking is everywhere useful and infants are encouraged to practice it; dodging missiles, fleeing from large strange beasts, fighting, hunting and other activities would be likely to be acquired everywhere in much the same forms because human structures and mechanisms and human environments everywhere are much the same.

It must be admitted that both of these objections are not unreasonable. It is really quite impossible to gen-

eralize with confidence from the test of universality or the existence of hereditary patterns of reactions in animals, concerning the instinctive equipment of man. Both of these lines of evidence are suggestive, but not conclusive. This being the case, it will be advisable to limit the inventory of specific instincts in man to observations and experiments based directly upon the human species.

The Observed Instinctive Motor Reactions of Human Infants.

Unfortunately, observations of the genesis and development of behavior in man—that is, studies of the human infant from birth—of a thorough and valid sort are very few and have been for short periods. Scarcely a single example of experimentation of the sort performed on birds, chicks and kittens, is to be found. Great uncertainty exists, therefore, concerning the character of nearly all of the complex acts which appear after the first few months of life. No more can be done than to present briefly the results of limited observations on infants together with a few speculations concerning later development.

The instinctive reactions in man may be grouped for convenience under the following headings:

1. Adjustments of the sense organs.
2. Seeking and accepting reactions.
3. Protective reactions.
4. Locomotion.
5. Vocalization.
6. Manipulation.

I. **Adjustments of the Sense Organs.**—Observations of infants during the first day of life (by Watson) indicate that all of the sense organs are functioning. Re-

sponses may be elicited through stimulation of the organs in the skin, the eye, and ear; taste and smell are probably active also. During the first day the infant shows the fairly complex adjustments of the head and eyes required to fixate a bright light. This means that the reactions resulting in the proper *regulation of the accessory apparatus of the sense organ* are native. The newly born infant seems capable, moreover, of *attention,* which involves not only adjustment of the sense organs but the curtailment of other activities and the making of certain complex neural adjustments. The young infant, in other words, is not merely a passive victim of sensory stimulation but it is from the first actively and to some degree, selectively, responsive to external influences.

A gradual progress of sensory control and of ability to attend or to isolate for sensory observation is apparent. For some time the infant fixates visually only very intense or mobile things. The definite visual fixation of the immobile human face or objects in the room appears clearly within a few weeks and later a disposition to explore actively with eyes, fingers, and tongue. These abilities seem to be native though they are clumsy and poorly coördinated at first. They correspond to the flowering of curiosity. Indeed, if we are not deceived by appearances, *the child early gives evidence of striving to comprehend the things and events about him.* He appears instinctively to be curious, to explore, to seek to learn.

2. **Seeking and Accepting Reactions.**—Since the adjustments of eye and ear to distant stimuli from the things about him—with the exception of a few very intense or striking events such as the moving light held near—appear some time after birth, the infant's earliest reactions are aroused mainly by stimuli from within the

body such as pangs of hunger, or by forces which impinge upon the body's surface. What we may call seeking or accepting reactions are early observed. The *food seeking and accepting reactions* are prominent. A slight touch on the face, especially the cheek, usually elicits a quick turning of the head, opening of the mouth and sucking reaction. When the infant is hungry, this response is surprisingly quick, often catching the stimulating finger. When the infant is satiated, the response may not appear or at least it may appear more slowly. The internal condition is an important factor here; the reaction is a response not wholly to the external stimulus alone but to a combination of the external and internal stimuli. When the child is hungry, it often appears to be seeking food. Repeated touches especially will set up active turning and mouthing movements. Swallowing completes this series of accepting movements.

Another form of accepting reaction is the *grasp with the fingers* which occurs when a harmless object touches the palm. So firm is this grasp that soon after birth the infant may be pulled entirely from its support, sustaining its whole weight with one hand closed about a small stick.

Other forms of accepting reactions take a passive form —*quiescence, repose, submission, inactivity.* These are, however, to be considered as positive reactions. The struggling brought about by interfering with breathing or movement, by hot or cold, and by pain, internal or external, gives way to relaxation when the infant is turned, or the stimulus otherwise removed. *Sleep* is undoubtedly the extreme form of quiescence and relaxation; it is quite as instinctive, quite as much a reaction to stimuli as sucking or grasping although the stimuli are undoubtedly complex, including both inner and outer

conditions. During waking hours, varied acceptance reactions are made to conditions which embrace moderate warmth, internal comfort, filled stomach, etc., and a certain freedom for movement. The responses to these conditions are *repose or playful activities plus what may be described as contentment.* The child's reaction is that of acceptance which may be contrasted with rejecting and struggling, to be described later.

The contented acceptance type of response, including attempts at *smiling and a cooing and gurgling that may contain the roots of laughter,* appears very early as the response to gentle stroking and manipulation of certain parts of the body, to gentle shaking, rocking, patting, etc. A little later, according to one observer (Watson) the child *extends the arms* when stimulated in these ways. Conceivably this is the initial stage of the embrace of love, although such an idea is speculative. *Sex behavior,* which does not appear in intelligible form until in the teens, must be classed among the instinctive reactions of the seeking and accepting type. As in food seeking, the hereditary stimulus in sex is partly or perhaps mainly an inner condition. To what extent the overt acts of courtship are inherited is at present problematical.

For some time after birth, the infant appears to grasp only those objects which come in direct contact with the body. According to certain observations (by Watson) the child is able to *reach and grasp objects seen at a short distance* at least by the end of the fourth month. Fairly effective *eye-hand coördinations,* such as the reaching and grasping of a watch, piece of candy, etc., then appear without earlier practice. Shortly the child appears to reach for all sorts of objects excepting only those which are too distant, too intense—such as paper burning in a metal basket, or a loudly barking dog—or too vigorously

active, such as a struggling pigeon. To such distant, intense or active objects the young infant reacts by *intent observation.* If the object comes nearer, or ceases to act in a violent manner, the infant usually attempts to seize it. For a time, the objects once clutched are usually carried toward the mouth, although a little later *manipulation* frequently follows seizure. Probably still later, it is instinctive to pursue such objects as small animals and capture them but it cannot be said with certainty that such reactions are hereditary. At least, *it is apparent that reaching and grasping are native responses elicited early by a large number of objects*—almost all small objects. Gradually the infant learns which of these produce pain or discomfort, and consequently soon fails to seize them; which are tasteful and henceforth carried to the mouth; which are noisy, mobile, etc., and henceforth are manipulated in various ways. Probably only the general coördinated acts of seizing, pulling toward the body, carrying to the mouth or variously manipulating are strictly native. The attachment of one of these forms of treatment, rather than others, to each particular object is acquired.

3. **Protective Reactions.**—A considerable number of reactions elicited by stimuli which are often, if not always, harmful appear immediately or shortly after birth. *Such reactions take the forms of avoiding or escaping from, of pushing off or getting rid of the stimulus, of struggling, or of other protective responses such as closing the mouth or eyes.* These early appearing reactions are often called prepotent since they take precedence over all others; they occur promptly at all times and may supplant other activities under way at the time. The biological utility of the prepotency of the protective responses is apparent.

Escaping Reactions.—To a number of physical contacts, the infant almost immediately after birth reacts by movements which usually result in escape from the stimulus. The foot or hand will be retracted from the application of a cold or hot stimulus, from a prick, tickle or pinch. If the stimulus is applied to parts not easily withdrawn, the infant will struggle until the body has been moved or the stimulus withdrawn. If the infant's face is placed in a pillow, it will promptly turn the head to the side. As the child grows older, more complex reactions of escape, including turning about and flight, make their appearance but as yet it is impossible to say to what extent these retreats are native. Doubtless the instinctive responses are rapidly and considerably modified by experience.

Rejecting Reactions.—To stimuli applied to certain parts of the body, the infant's reaction is a thrust or push which often results in getting rid of the stimulus. During the day after birth, infants will push off with the one foot the hand of the investigator which pinches lightly the other knee. Very early the hands will push at pressures applied to upper parts of the body, such as the nose. To a strong stimulus, the infant's response is quite prompt and vigorous. If the pinching persists, the thrust becomes more violent, and may be accompanied by widespread bodily struggling and crying.

Pushing substances from the mouth with the tongue, vomiting, sneezing and coughing are early appearing native reactions which result in the rejecting of undesired and harmful substances. To sticky and dirty substances placed on most parts of the body, the infant pays little attention, i.e., there are few if any instinctive reactions to secure cleanliness.

Struggling and Fighting.—When the head, arm, nose

or other member of an infant is held in such a way that withdrawal from or removal of the restraining force is not at once achieved, there at once begins a struggle which becomes more violent until the whole body is engaged. Crying or screaming usually accompanies the struggle. In such activities are forms both of repelling and escaping reactions; the infants struggle either to throw off the offending stimulus or to escape it. These activities constitute the earliest form of fighting; a response which is clearly instinctive. In later years, fighting continues to be an instinctive reaction to persistent interference with locomotion, eating, sleeping or other activities. Fighting takes on new details of form as the body develops; the native responses consist in the use in a violent and directed form, of all of the weapons—arms, fingers, legs, feet, and possibly teeth—with which the species is equipped. Instinctive struggling and fighting are violent but nevertheless crude. In contests among individuals equal in strength, the trained boxer or wrestler is markedly superior. Even in such primitive activities, it is possible to improve vastly on native behavior.

4. **Locomotion.**—The mature forms of locomotion—walking and running—involve a number of complex activities that do not appear at the same time. Holding up and balancing the head appear early and are doubtless native. Turning the body about while lying down has been observed within the first week. *Creeping,* the first form of locomotion, varies so much in character among different infants as to suggest a considerable influence of learning. *Standing erect and walking* do not appear at first in as fully perfected form as does flying in birds or walking in calves and other species yet many maintain that the maturation is native though slow.

Conclusive observations or experiments are not as yet available. The same *uncertainty prevails concerning running, climbing, balancing on a moving object* such as a wagon, etc. *Swimming is certainly not instinctive;* young infants show great fear and no useful activities when immersed in water.

5. **Vocalization.**—The native oral responses appear to be few and simple. Certain types of *crying and screaming* appear at birth in response to cold and various pains, hunger, being held tightly and other discomforts. *Cooings and gurgling* appear during pleasing experiences and probably a sort of *laughter* is native. In addition to these, a considerable number of single sounds appear in innumerable arrangements none of which is very stable or characteristic. Out of these elementary oral responses, complex patterns are acquired as the result of practice. Nearly all of the individual enunciations—shouts, whimpers, sing-songs, etc., as well as the speaking language, are patterned after models which its surroundings provide. The human vocal apparatus, like those of other species, has its limitations; not every type of sound pattern can be imitated however great and prolonged the practice.

6. **Manipulation.**—Aside from the manual reactions already described under seeking and accepting and under protective activities, the well formed native adjustments of a complex character are few. As in vocalization, nearly all of the manual abilities of the child of six or of the adult are learned. The degree of difficulty encountered in learning a particular ability—holding a spoon, turning a key, whittling, etc.,—depends mainly, however, upon the native limitations of the hands in both structure and inherent aptitude. The first of these is the inherited characteristic of *handedness,* ranging from a pro-

nounced superiority of the right hand through ambidexterity to left-handedness. Estimates of the number of natively left-handed vary from two to six per cent; the ambidextrous are few, leaving over 90 per cent right-handed in various degrees. Efforts to force the use of the natively inferior hand, of "going against nature" in this way, result frequently in nervous disturbances. Similar native differences exist among the digits of either hand; the two fingers adjoining the thumb are more mobile and adaptable than the other two. The usual form of holding a pencil in writing has resulted doubtless from the discovery of the greater ease of learning when the chief work is done with the thumb and first two fingers with the other digits playing a supplementary rôle. It would be a more difficult task to learn to write by placing the burden of activity on the last two fingers.

Conscious Reactions, Native and Acquired

Native Equipment for Conscious Reactions.—The machinery for conscious action is given by nature quite as muscles and glands are and it would be surprising if there were native responses of the latter and none of the former. It is, we think, a most plausible assumption that the infant has conscious experiences from the moment his sense organs and muscles begin to act in relation to external situations. What types of conscious processes probably appear immediately after birth and which ones are, presumably due to native capacities, that is, to inborn organizations, of the neural apparatus?

Sensations.—Doubtless *sensory experiences* or *sensations* are experienced at once. These processes will embrace, at least typically, qualities determined by the particular sense organs and cortical neurones stimulated. By qualities we mean the color, red or blue, the taste

sweet or sour, the tactile experience pressure or cold. How much more than these qualities are experienced in the infant's first contacts with light waves or other stimuli from objects in the environment, that is, how much the experience embraces awareness of position, size, shape, distance, or significance, such as desirability or undesirability, we cannot tell. Certainly most of that which makes up the significance of the stimulating situation is acquired during later experience.

Feelings and Emotions.—The feelings of *pleasantness* and *unpleasantness* and various *emotions* such as joyfulness, fear and anger are doubtless within the child's early conscious experiences. The physical organizations underlying these feelings and emotions are native and the observable behavior of infants suggests that soon after birth appropriate stimuli throw the mechanisms into action.

Impulses.—An impulse is a conscious experience which precedes some action. It is the awareness of the state of readiness for some response. It is felt as an urge to carry through the reaction for which one is prepared. When on the verge of a sneeze, the impulse to sneeze is clearly conscious. When hungry, we feel an impulse to secure and eat food; when tired, an impulse to rest; when sad, an urge to weep. The infant doubtless experiences impulses of many sorts and some of them, such as the impulse to rest, sleep and eat and perhaps others, are native.

Percepts, Images, and Ideas.—In addition to sensations, feelings, emotions and impulses, adults have a rich life of conscious experiences based upon facts acquired through sensory perception and later recalled during recollection, imagination, day dreaming, reasoning and other types of thinking. Things, complex events, facts

of all kinds come to be known to us by use of the senses. These facts are not given us by nature but grow out of our experience. What is given us by nature is merely the machinery for learning and an urge to learn. The facts themselves, all forms of knowledge, are acquired. Facts which come to us through use of the senses may be recalled when no sensory stimulus is present. Recalled facts are the materials with which we think. The facts with which we think are acquired. In other words, though the capacities to acquire facts during sensory perception and to recall facts are native, our particular percepts, images and ideas are acquired.

In chapters to follow, the nature and significance of sensations, feelings, emotions, impulses and urges, the capacity to learn and think, and the processes of acquiring facts will be treated in detail.

QUESTIONS AND EXERCISES

1. Do you judge that the text would harmonize with this statement: "Because the mother was terrified by an accident before the birth of the child, the offspring has always shown an unusual fear at the sight of blood"?
2. Criticise or defend this argument. "Since birth is only an event in the development from the embryo to adulthood, the appearance at birth of activities and impulses, which could not have been acquired, sweeps aside all theoretical objections to the appearance at any time of inherited activities and impulses."
3. Which of the following are most likely to be native, which acquired? Why?

Situation	*Response*
a. Sight of a gun	fear
b. Food in mouth	salivary secretion
c. Sight of a bear	fear
d. Dark quiet place	impulse to lie down and sleep
e. Shouting in the distance	run toward sound
f. Small animal in sight	chase it
g. Being crowded	anger or irritation

4. Which of the following expressions are incorrect?
   a. Instinctively, he threw up his hands to block the blow.
   b. He has practiced dancing until it is instinctive with him.
   c. Caruso always had an instinct for music.
   d. I am instinctively opposed to the idea of prohibition.
   e. This tribe seems to be instinctively ferocious.
   f. They have inherited an instinct for skilled fishing.
5. Would the human being be better equipped for life if he had no instincts at all but began with a clean slate? When do you think the human instincts are most serviceable, during the first three years or later? Explain.
6. Prepare a theoretical argument in favor of or opposed to the thesis: "The activities of most animals are based more fully on instincts than are the activities of man."
7. Make a list of the hereditary human reactions enumerated in the text and indicate those which you believe are native and those which you believe acquired or doubtful. Add other activities which you believe should be included among the instincts.
8. Utilizing the final list worked out in (7) attempt to classify them (a) according to the function served; (b) according to the type of reaction made and (c) according to some criterion of your own. What difficulties are encountered?
9. What evidence have you to show that it is or is not instinctive to catch an object (such as a ball) which is thrown toward a person. How universal is this reaction? From what per cent of your fellow students would you secure it? Of young children? Of old people? What other reactions may be found?
10. Of what value would knowledge of the native motor reactions made when a human being is thrown in the water be to an instructor of swimming?
11. Is it assumed that men inherit ideas of right and wrong, of honesty, etc.?
12. What is meant by a "prepotent" reaction? What biological usefulness is suggested by the existence of certain prepotent instincts?
13. How would you determine whether climbing trees is native or acquired?
14. Discuss this opinion of John Dewey, "The native stock of instincts is practically the same everywhere. Exaggerate as much as we like the native differences of Patagonians and Greeks,

Sioux Indians and Hindoos, Bushmen and Chinese, their original differences will bear no comparison to the amount of difference found in custom and culture—the countless diversity of habits springs from practically the same capital stock of native instincts."

GENERAL REFERENCES

No treatment of the instinct theory equals in importance that of Charles Darwin, which appears in his *Descent of Man,* 1871. William James, in his *Principles of Psychology,* New York: Henry Holt, 1890, vol. II, Chap. 24, gives an interesting and another historically significant discussion of the instinct hypothesis. Another important treatise is William McDougall's *Social Psychology,* Boston: John Luce & Co., 1908. McDougall's views, slightly modified since the publication of the earlier work, appear in his *Outline of Psychology,* New York: Scribner, 1923. An excellent account of the instinctive equipment of man is contained in R. S. Woodworth's *Dynamic Psychology,* New York: Columbia University Press, 1918. The most extensive discussion is in E. L. Thorndike's *Education Psychology, Vol. I, The Original Nature of Man,* New York: Teachers College, 1913.

An interesting account of the unlearned activities of certain birds and animals will be found in an article by D. A. Spalding, "Instinct, with Original Observations of Young Animals," reprinted in *Popular Science Monthly* (now the *Scientific Monthly*) June, 1902. A comprehensive survey of experiments and observation upon animal instincts will be found in John Watson's, *Behavior, An Introduction to Comparative Psychology,* New York: Henry Holt, 1921.

The observations of activities of infants utilized in the text will be found in John Watson's, *Psychology, From the Standpoint of a Behaviorist,* Philadelphia: Lippincott, Revised Edition, 1924, Chap. 7.

Of the many critical discussions of the instinct theory, the following are representative of the extreme and intermediate positions:

Knight Dunlap, "Are There Any Instincts?" *Journal of Abnormal Psychology,* 1919-20, vol. 14, pp. 307-311. E. C. Tolman, "Can Instincts Be Given Up in Psychology?" *Journal of Abnormal and Social Psychology,* 1922-23, vol. 17, pp. 139-152, and "The Nature of Instinct," *Psychological Bulletin,* 1923, vol 20, pp. 200-218. F. H. Allport, *Social Psychology,* Boston: Houghton Mifflin, 1924, Chap. 3.

William McDougall, "The Use and Abuse of Instinct in Social Psychology," *Journal of Abnormal and Social Psychology,* Dec., 1921, and March, 1922. Z. Y. Kuo, "A Psychology Without Heredity," *Psychological Review,* Nov., 1924.

REFERENCES TO STUDIES UTILIZED IN THE TEXT

B. T. Baldwin and L. I. Stecker, *University of Iowa Studies,* Vol. 2, No. 1, 1922.

D. A. Spalding, "Instinct and Acquisition," *Nature,* October, 1875.

R. M. Yerkes and D. Bloomfield, "Do Kittens Instinctively Kill Mice?" *Psychological Bulletin,* 1910, p. 253.

F. S. Breed and J. F. Shepard, "Maturation and Use in the Development of an Instinct," *Journal of Animal Behavior,* 1913, p. 274.

CHAPTER VI

SENSATIONS AND FEELINGS

Sensation is a native response in the sense that we are born with sense organs, sensory nerves and brain, so arranged that the stimulus will produce the conscious response soon after birth as soon as a certain stage of inner growth is achieved. The stimulus, after the first few hours of experience at least, arouses a conscious response more complex than sensation. It arouses percepts of things and events, which immediately follow the sensation. The exact nature of the percepts is determined greatly by experience but the sensation, which is the bare awareness of the qualities of objects, is more uniform and little influenced by experience except in so far as the sense organs, nerves or brain may be injured by work, accident, disease, etc. Sensations are distinguished from each other chiefly by their qualities—as redness is distinguished from cold—and a considerable portion of the chapter will be devoted to a study of sensation-qualities.

Sensations and feelings will be treated together in this chapter partly for the reason that they are rarely separated in popular speech and partly because some investigators hold that all of the experiences which we call "feelings" turn out to be groups of sensations. In ordinary conversation we say: "I feel—cold, hot, excited, pleased, hungry, angry," but we do not say, at least for literal interpretation: "I feel—green, salt, aromatic, or

noise." In the latter instances we say: "I see a green color," "I taste salt," "I smell an aromatic odor," or "I hear a noise." Apparently, we say that we see, hear, taste or smell or, in general, that we sense things which are experienced through these special senses, but that we "feel" conditions in or on the body. One of the tasks before us in this chapter is to ascertain what the differences, if any, are between all of these experiences. To accomplish this task we must begin by describing and classifying sensations. An understanding of the nature of sensations and feelings will pave the way, moreover, for a discussion of emotions which, according to one theory, are really complex blends of sensations.

Sensations of Taste

The problems involved in the analysis of sensations in general are illustrated by those encountered in studying tastes. First, it is necessary to be sure that the sensations grouped under taste are really gustatory sensations and not some other sort, such as odors or skin sensations. In many of the studies, therefore, introspections are taken before and after the sense organs of smell have been bottled up by plugging the nasal passages, or the sense of pain or touch is temporarily abolished by drugs. Most introspective study is carried on under such controlled conditions. Second, it is necessary to test the effects of all possible sorts of normal stimuli lest some kinds of sensations be overlooked. This means at least sampling a very large variety of substances, the sensations aroused by which are carefully observed and the similarities to and differences from others noted. The task is eventually to ascertain what are the really primary or elementary tastes and which are compounds of these.

Ways in Which Sensory Experiences Differ.—There

are an immense number of different tastes. By "different" we mean "distinguishable." In distinguishing one taste from another, it is found that various clues are utilized. First, some tastes which are about the same in quality, may be discriminated because of differences in *intensity*. Solutions of salt are all alike in being "salty" but some are stronger or more intense than others. All sensations differ similarly in intensity:—lights, sounds, pains, all vary from very weak to very intense. Second, some tastes are alike in quality, such as saltness, and in intensity or strength but differ in what is sometimes called *extensity* or amount. A given salt solution may be applied to the taste buds in small areas of the tongue or to all of the sense organs by taking a large mouthful. The quality and intensity of the sensations may be made about the same but as a whole the experience differs because of the extensity of stimulation. Most other sensations, lights, pressures, or pains, may be distinguished on the basis of the amount or extent of the area stimulated. Third, sensory experiences, alike in quality, intensity and extensity may differ in *duration*. A taste of salt, a sound, color, pain, etc., may last different lengths of time. Variations in the intensity, extensity and duration of the sensory experience make possible a large number of discriminable effects. The main problem, however, is to ascertain in all the possible distinguishable sensory experiences the elementary, irreducible *qualities*.

The Primary Tastes or Taste Qualities.—In the case of taste, introspective study has revealed that in all the discriminable sensations, there are only four distinct taste qualities, namely, *sweet, sour, salt* and *bitter*. These tastes are called *elementary sensation-qualities* (or we may to avoid monotony sometimes call them

primary or elementary tastes) since they cannot be reduced to anything simpler.

Compound Sensations or Sensation Qualities.—Most substances which we taste arouse at once more than one of these qualities in some degree. Lemonade really produces the qualities sweet and sour; grapefruit yields a combination of sweet, sour and bitter. Like lemonade or grapefruit, most other foods such as sweetened chocolate or ice cream, while usually conceived to have a more or less unified taste, are really combinations. They are called *compound sensations* or *compound sensation-qualities* since they may be reduced to two or more of the primary qualities. Since any degree of intensity of any one taste may be combined with each of many degrees of intensity in one or more of the other three tastes, the total number of compound tastes which may be produced is enormous.

Blends of Tastes with Other Types of Sensation Qualities.—Experience seems to conflict with the idea that all tastes are limited to combinations of these four primary qualities. We think that we are sensitive to fine differences in the "tastes" of potatoes, turnips and carrots; indeed, we are aware of differences in the same vegetable in accordance with the way it is cooked. Introspective study has shown, however, that most of these distinctions are due not to differences in taste but to variations in other types of sensations, especially to odors, pressures, muscular sensations and pain.

Tastes are confused with odors very readily. Juices extracted from onions and potatoes taste almost alike when the organs of smell are bottled up by a plug in the upper nasal passageway. Under these conditions coffee and a weak solution of quinine taste alike, slightly bitter; certain wines taste like weak vinegar; many fruit juices

taste alike except for variations in sweet and sour. The odors of these substances are far more important characteristics than tastes.

Sensations from the linings of the mouth and nose also fuse with tastes and odors to make a total experience which we mistake for mere taste. Raw and mashed potatoes taste the same but feel different in the mouth. Cold coffee is different from hot not at all because of taste, not wholly because of smell but partly because of the coldness and heat. Charged water tastes the same as uncharged but it bubbles, stimulating pressure sense organs, and by influencing other nerve endings produces a mild sting. Spices are almost wholly odors and sting; peppermint is almost wholly odor and cold; olive oil, castor oil, and unsalted butter differ only in smell and "feel." Nuts differ from mashed potatoes partly in odor and partly in the muscular sensations aroused in chewing as well as in impressions on the surface membranes.

The Stimuli which Arouse Taste Sensations.—The stimuli which arouse the sense organs of taste are chemical substances in liquid form. Doubtless some general chemical composition is found in all substances which taste sweet or sour or salty or bitter but it is not now possible to write the general formula corresponding to each taste.

Sensations of Smell.

The sensations of smell, which may also be called olfactory sensations or odors, result from the action of chemical substances, dissolved in air, upon receptors in the nasal cavity. The total number of discriminable olfactory sensations is very large and until recently identification of the primary qualities and the classification of odors under them have been far from complete. The

recent investigations of Henning—who trained himself to a high degree of expertness in this field—have yielded the nearest approach to an analysis of odors. He finds six elementary odors or olfactory qualities as follows, each corresponding to a characteristic of the chemical stimulus:

1. Fruity odors, such as are found in apples, grapes, orange oil, vinegar, etc.
2. Flowery odors, found in pansy, carnations, etc.
3. Spicy, found in cinnamon, cloves, nutmeg, etc.
4. Resinous, found in pitch, balsam, turpentine, etc.
5. Smoky, found in burnt substances, tar, pyridue, etc.
6. Putrid, found in decaying matter, limburger cheese, hydrogen sulphide, etc.

As in other sensations, the pure odor is rather rare; compound odors which may be reduced to two or more of these six elements are the rule. Variations in the relative intensity of the component odors make the total number of combined olfactory sensations very large.

The Relation of Stimulus to Sensation in Taste and Smell.—The first curious relation of stimulus and response in the case of taste and smell appears in the phenomenon of *adaptation*. After the stimulus is applied the response—the taste or odor—rapidly rises to a maximum and then, although the stimulus is continuously applied as at first, the conscious reaction gradually decreases in vividness. When you enter a paint shop or candy store you may note that the characteristic odor, at first very vivid, gradually decreases in intensity. The clerk who has been subjected to the stimulus a long time scarcely notices it at all. Adaptation occurs to taste stimuli too. After eating a dish of ice cream, it always requires more sugar to get the desired sweet sensation

from the coffee. By the usual lump, only a weak sensation of sweet would be aroused. Adaptation, then, describes the fact that the response gradually decreases in vividness with prolongation of a stimulus. Adaptation is much like fatigue yet it differs from muscular fatigue. It is much quicker than the fatigue resulting from normal muscular action, and the recovery is usually more prompt. Wash out the mouth, especially with a sour substance, and the sensitivity to sweet quickly returns. Take a few breaths of fresh air and sensitivity to an odor reappears. Adaptation, moreover, does not give us any conscious symptoms of fatigue as continued muscular work does, and, furthermore, adaptation has definite beneficial results in some instances at least. These beneficial results appear clearest in vision during the discussion of which we shall return to the topic.

Another peculiarity in the relation of stimulus and response appears in the fact that adaptation to one stimulus often increases the vividness of the response to others. Adaptation to sweet increases sensitivity to sour; adaptation to sour increases responsiveness to sweet; tasting a salt solution heightens the effects of both sour and sweet, and tasting bitter increases sweet. Similar effects are found in reactions with odorous stimuli and in vision we shall see the most pronounced results. These effects are often called *successive contrast effects*. *Simultaneous contrast effects,* in which the presentation of one stimulus brings about a more active response to another applied at the same time, are apparent in vision but not so clear in taste and smell.

Another phenomenon is the *after-sensation,* the continuation of a sensation after the external stimulus has been removed. This occurs in all senses, most pronouncedly in vision. The internal response lags behind

the stimulus when it is applied and it continues after it has been removed. The inner machinery, once it gets under way, requires a few moments to halt and until it has ceased activity the sensation may persist. We shall turn now to vision where these phenomena and some others may be actually demonstrated.

VISUAL SENSATIONS.

In describing the qualities of visual and other sensory experiences, care must be exercised to distinguish between the stimulus and the response since they are habitually confused in every day speech. Red and green and other colors are sensations. They are conscious states; they exist only in us. They are our conscious reactions to the stimuli. The stimuli are waves in the ether; they are not colors. When we say the apple is red we are really speaking a little loosely since the red is not in the apple but in our consciousness. The apple merely reflects from its surface to the eye certain ether waves. There are some persons who are quite or nearly color blind. The light waves from the apple arouse in them not a red sensation but a gray. The stimuli for the two observers were the same but the reactions were different.

In the laboratory, the investigator usually utilizes colored papers as a means of securing visual stimuli. A "colored" paper is one which reflects into the eyes only certain light waves, having absorbed others. A "red" paper is one which reflects into the eye primarily those light waves which arouse in the observer the *sensation* red; a "blue" paper reflects those waves which arouse the *sensation* blue. Such papers, therefore, provide a convenient means of securing visual stimuli.

Elementary Visual Sensation-Qualities.—The quali-

ties of visual sensations are usually divided into two groups, the colors and colorless qualities. A great many colors are given particular names: red, orange, yellow, yellow-green, or olive, green, green-blue or peacock, blue, indigo, violet, purple and others. Are all of these color qualities elementary or may they be reduced to a small number from which others are made by combination?

According to most observers all of the thousands of discriminable colors contain only the qualities of four, namely, *red, yellow, green and blue.* These four are therefore called the primary or elementary color-qualities. That all other hues are really not totally unlike these four may be disclosed by studying the sensations set up by pieces of "colored" paper. Start with red, comparing it with orange. Now a deep orange has a reddish hue, and contains also a tinge of yellow, but no one can see in orange anything wholly different from these two. It seems to be a mixture or blend of red and yellow. Some oranges are very much like red; others closely resemble yellow. Indeed one may arrange a whole series of orange hues, beginning with red and terminating with yellow. Yellow is not exactly a sharp point in this belt since these are several perceptible hues where it merges with orange, that may better be described as different yellow hues rather than as very yellowish oranges; the blending is very gradual. On the other side of yellow, it is possible to select a series of hue which, beginning with yellow ever so slightly tinged with green, later becomes about an even mixture which merges finally with pure green. Beyond green may be arranged another series, at the middle of which is a blue-green, approximately what is sometimes called peacock. Blue-green gradually merges with genuine blue. Other hues left on our hands now are indigo, violet and purple.

Indigo is certainly much like blue with a slight tinge of red, the color from which we started in arranging the belt of colors. Violet and purple are even more like red and crimson is very much like red with a tinge of blue. Indeed, these colors are steps in a continuum between blue and red. Thus, all of the colors sensations are continuous, forming a belt which describes a circle, the *color circle.*. The whole series consist either of red, yellow, green and blue, or a blend of any two of these which are adjoining in the circle.

The Colorless Visual Qualities—Black and White.—In addition to the colors, there are two other visual qualities, black and white, which have a claim to inclusion in the groups of elementary sensation-qualities. White, introspectively, is not like red, yellow, or any other color nor is it like black. The same is true of black; it is itself and nothing else. Both are distinctive sensations which must be included in the group of elements, along with red, yellow, green and blue.

Just as there is a series of blends, between adjoining primary colors, so there is a continuum between white and black. Gray is a sensation resembling both white and black just as orange is a sensation resembling both red and yellow. White and black are called primary for the same reason that red and yellow are. The primary visual sensation-qualities, then, are six: red, yellow, green, blue, white and black. These are called elementary because in any particular visual sensation whatsoever we find no qualities that are utterly different from any of these.

Compound Visual Sensations.—While all of the colors may be reduced to four primary color-qualities, red, yellow, blue and green, there are many intermediate or compound colors, such as orange and blue-green in the

circle of purest or most saturated colors. In the whole circle of colors, the average person can distinguish about 160 colors, in the sense that he can perceive a difference between each and the others. A certain orange is perceived, for example, as slightly more reddish than those adjoining on one side and more yellowish than those adjoining on the other side in the circle. By going completely around the circle in this manner, about 160 different stages can be distinguished.

Any one of these distinguishable colors, whether pure green, slightly bluish-green, slightly yellowish-green or whatnot, may be combined with any shade of gray, thus producing what we call shades of the color. If we mix a certain vivid red with gray of identical shade or brightness, the result is a quality combining red and gray. We do not see each quality separately, of course. The result is a compound sensation; the qualities are fused. What we see is a duller—not a darker or lighter—red. The red, without becoming darker or lighter, that is, without changing its shade, becomes less full, vivid or saturated. Adding more gray, further dulls the red without changing its essential red quality. If you keep on adding gray, the red gets less and less saturated until it is swamped altogether, leaving only gray. Similarly, any color may be mixed with a gray of its own shade or brightness, and when so mixed the result is a sensation possessing both the qualities of gray and the color. The changes are called changes in saturation. Adding gray reduces the saturation.

Colors can be changed in another way which may be described introspectively, as the mixing of the color quality with a gray of a shade *lighter or darker* than the saturated color possesses. In the grays, ranging from the brightest white to the deepest black, an average person

can discriminate about 700 steps. Only one of these shades of gray exactly matches in brightness the shade of the color when it is most vivid or saturated. Now, by adding to the saturated color, say red, a lighter gray, the effect of a lighter shade of the red quality is produced. A darker gray fuses with the same red to produce a darker shade of red. Pink, for example, is introspectively a mixture of red and light gray; it is lighter and also less saturated than the most vivid red but it contains only the qualities of redness and of grey. Since gray may be reduced to black and white, pink includes the qualities of red, black and white, in which white predominates over black. Olive is, introspectively, a blend of yellow and green, and moderately dark gray, i.e. of yellow, green, white and black. Brown, similarly, is a combination of dark gray (or white and black with the latter predominating) and orange (or red and yellow combined). Every visual sensation, then, may be reduced in this way to the primary qualities, red, yellow, blue, green, black and white. Most sensations are compounds of these qualities. Counting all of the primary qualities and all combinations, the total number of distinguishable sensations amounts to at least 30,000 for the average person.

We shall next consider the character of the stimuli which arouse visual sensations. In vision the relations of the stimuli and the conscious reactions, the sensations, are unusually complex due to the fact that different stimuli will activate the same responses.

The Stimuli for Visual Sensations.—Stated in terms of the lengths, or distance from crest to crest, light waves which affect the retina form a continuous series from about 760 to 390 millionths of a millimeter. When waves of the same length strike the eye, particular colors sen-

sations are activated. Some of the light waves with the corresponding sensations are as follows:

Wave Lengths in Millionths of a Millimeter	*Color Sensations*
760–646	reds
647–587	oranges
588–549	yellows
550–491	greens
492–454	blues
455–390	violets

It will be understood that the color sensations are not sharply divided but are continuous as described above. Each wave length produces a particular sensation; wave length 577 produces what is generally accepted as primary yellow; 587 would be a very yellow with a tinge of red; 567 would be a greenish yellow.

The stimulus series is straightforward in its correspondence to the steps on the color circle, with two striking exceptions. The waves for violet and red, colors similar as sensations, are at the extremes of the series, 760 for red, 390 for violet. Between violet and red, resembling both, is the color hue purple, which, unlike all the others, is not produced by single light waves, but by various combinations of those which singly produce red and violet. Neither of these facts would be suspected from the study of the color sensations alone.

Color Mixing.—While every light wave in the visible range produces some specific color hue,—a statement which cannot be reversed, because of purple—every hue may also be produced by mixtures of two or more different light waves; and what is the more surprising, grays may be produced by mixing two or more light waves, which singly would produce a color. These facts may be illustrated readily by mixing light waves, but to do

so we must be sure that we are mixing light waves and not something else, such as dyes or other pigments.

The most convenient way to "mix" light waves is to place sectors of colored paper in a color wheel which, when rotated at high speed, gives roughly the same effect that separate light waves would have if they came from identical positions in space at the same time. Mixing paints is not the same as mixing light waves and different results may be obtained.

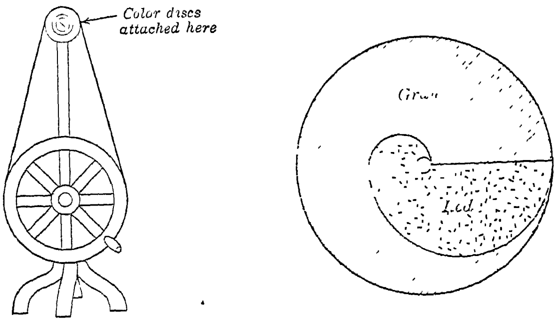


FIG. 27.—DIAGRAM OF A COLOR MIXER AND A COLOR DISC. In the disc the striped section indicates gray of the same shade (brightness) as the mottled sector of red. If this disc is rotated rapidly, the center will be a vivid or saturated red which becomes less so until at the circumference the sensation will be gray, i e., unsaturated. The whole disc will be of the same shade or brightness.

Color Blends.—If we place in the color mixer a sector which alone gives a red sensation and another which gives yellow and spin the wheel rapidly, the resulting color is orange the exact hue of which will depend on the proportions of the two color sectors. According to subjective analysis orange was judged to be a blend of yellow and red and was placed between them on the color circle. Mixing yellow with green gives an intermediate hue, yellow-green; mixing green and blue, gives a green-blue and mixing blue and red, will give, depending on the

proportion of each, indigo, violet or purple. In these samples the mixing of stimuli which singly gave primary colors, such as red and yellow, give a sensation which is a blend. Similarly, the mixing of two color stimuli, one from either side of a primary, such as orange and yellow-green, gives the primary color yellow which lies between them. Thus all around the color circle, mixing two adjacent colors gives the intermediate hue.

Strictly speaking, colors are not mixed in these experiments. Colors are sensations; they exist only in the subject's consciousness. What are mixed are the external stimuli, namely, the light waves thrown off by the sectors. The experiments illustrate, not the fusion of sensations in the mind but the way in which different combinations of stimuli produce the same effect as a single stimulus.

Color Complements.—Mixing wave lengths somewhat further apart than those which yield the blend will frequently result in colors that are rather dingy and lifeless, lacking the saturation of either of the single colors. If just the right two waves are selected, for example, a certain blue and yellow, the result is not a blend; indeed, it is no color at all but gray. The same effect may be secured by mixing the stimuli which singly produce

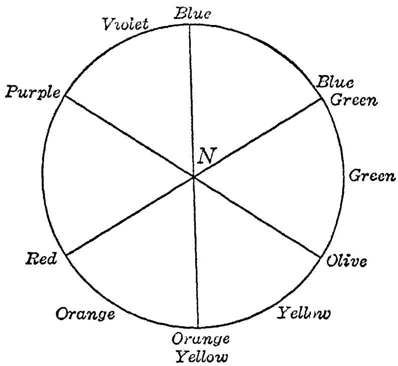


FIG. 28—COLOR CIRCLE MODIFIED TO SHOW COMPLEMENTARY COLORS. When a line is drawn through the center N (for neutral gray), the two colors indicated where the line cuts the circumference will be complementary and when mixed will give the neutral gray.

orange and a certain blue-green; violet and a certain yellow-green. The modified color circle in Figure 28 indicates other pairs of stimuli; which when mixed produce sensation of colorless gray. Pairs of light waves which when acting together produce a colorless gray, are said to be complementary. For convenience in expression, the colors corresponding to the two complementary light waves are often called complementary colors or complements.

The exceptions to the rule that two complementary light waves when mixed produce gray are certain greens which include the primary green—a vivid grass green. To get gray, the light waves for these greens must be mixed with those which produce purple. But purple, as stated above, cannot be produced by a single wave, only by mixing two, the long waves which give red and the short waves which yield violet. Thus a mixture of three is required to give gray when one is the wave for certain hues of green.

Positive After-sensations.—There are other peculiarities in the relations of visual stimuli and the conscious responses, of which the phenomenon of *after-sensations* is one. Arrange in a dark room on a dark surface a piece of paper upon which the rays from a desk lamp may be turned. After a few minutes in the dark, switch on the light and gaze steadily at the paper for several seconds. Then switch off the light. If the eyes are now held steadily, the sensation of white will persist for a moment. The sensation continues after the stimulus is removed. This phenomenon is called the "*positive after-sensation.*"

Negative After-sensation.—If the eyes were held steadily after switching off the light, the positive after-sensation gives way very soon to what appears like a very dark patch, the shape of the paper, on a field of

lighter gray. This appearance is called the *"negative after-sensation."* It may be observed by fixating Figure 29 for 20 seconds and looking away to a gray wall. It may be obtained also from colors. Fixating yellow results in a negative after-sensation of blue; blue gives an after-sensation of yellow, red gives a blue-green and so on; every color stimulus results in not only the sensation and the positive after-sensation but a negative after-sensation. The negative after-sensations, it will be observed, are of the hue of the complementary colors.

Fig. 29.—Look at the Figure Without Moving the Eyes for 20 Seconds, Then Gaze at a Gray Wall Steadily.

Adaptation.—The negative after-sensation, or what is really equivalent to it, occurs during continued exposure of the eye to any light, constituting what is called *adaptation* to the stimulus. When one comes out of a dark room after experiments on after-sensations, the daylight is at first dazzling but by degrees one becomes adapted to it; the sensations become less white and more gray. If one returns now to the dark room at first the sensations are deep black but after a time they are less black and more like dark gray. Similarly in gazing continuously at a color, we become adapted; and adaptation results in a hue sensation of less fullness or saturation. This is most clearly illustrated in wearing colored glasses; as time goes on, we become less sensitive to the color of the glass so that things seen through it are more natural. If you suddenly jerk off a pair of yellow glasses after

having worn them for a time, you will notice that many things appear with a bluish tinge. If you look at a blue object, it appears more vividly blue than usual, just as when you come out of a dark room, white or gray objects look more white than usual. Adaptation then consists in gradually getting less full or vivid sensations from a light stimulus continuously active and in increasing the sensitivity to the complementary stimulus. By exposure to light waves for blue, we secure a great sensitivity to yellow and secure more vivid sensations of yellow. Yellow is the complement of blue and it is also the negative after-sensation. These three phenomena are apparently related and to them may be added a fourth, *contrast.*

Contrast.—Take two pieces of identical gray paper, and place one on the center of a sheet of black and the other on white. The piece on the black ground will now appear lighter than the one on the white ground. Now place one of the identical grays on a blue ground and the other on red. Cover both with thin white tissue paper—since obscuring the breaks between the colors makes the contrast effect more pronounced—and the gray on blue becomes tinged with yellow, the one on red with blue green, the complementary colors. Placing a small piece of red in the center of a sheet of blue green results in an accentuation of the redness. The complementary or contrast effects will not appear always, in fact, in ordinary life they are little noticed. Conditions must be just right; lines of division must not be too sharp and reflection of light from one to the other must be avoided. For example, a woman who wished to emphasize the bloom of her cheeks would not surround her face with a blue-green hat of extending brim. The result would be a pallor, since some of the blue-green light

reflected by the hat to the face would be reflected again from the face to the eye along with the red from the cheeks. Red and blue-green lights, coming from the same surface, are antagonistic and tend toward gray. If

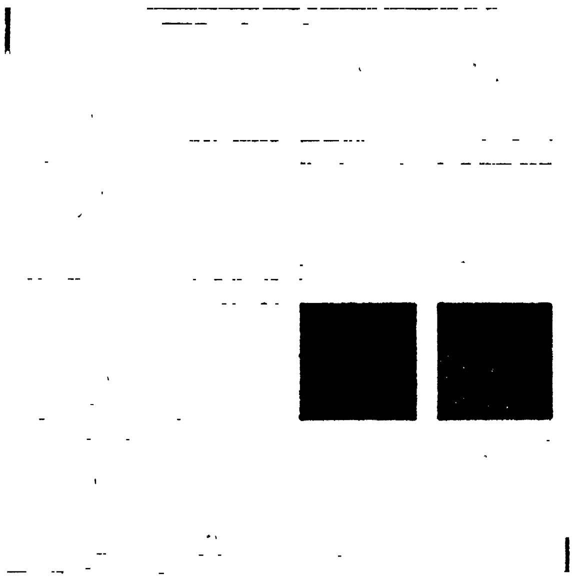


FIG. 30.—A CASE OF BRIGHTNESS CONTRAST. Note the apparent shadows which appear at the intersections of the white strips. (From M. Luckiesh, *Visual Illusions,* New York: D. van Nostrand Co.)

the face appeared, however, on a background of green, especially at a distance, the contrast effect would result in an accentuation of the pink from the skin.

Chemical Processes the Immediate Visual Stimuli. —The relations between the objective stimuli, the light waves and the conscious reactions, the sensations, are rather complex as we have seen. Such facts as adaptation, contrast effects, after-sensations, etc., are apparently due to chemical activities in the retina in which the receptors are imbedded.

Theories to Account for the Rôle of the Receptors in Vision.—The precise nature of chemical activities in the receptors and surrounding retina, following stimulation by light waves, have never been directly observed. They are subjects of speculation entirely. Any hypothesis to be acceptable must take into account and explain all of the facts of vision. It is not generally conceded that any one of the several theories suggested explains satisfactorily all of the facts now fairly well established. Since many particular facts, upon which such hypotheses must be verified are still obscure, no theory can be very thoroughly tested at present. The hypothesis favored by a number of psychologists as best fitting the most facts known at present, was devised by Christine Ladd-Franklin and is usually known as the Ladd-Franklin Genetic Theory.

The Ladd-Franklin Theory.—The Ladd-Franklin theory starts with the assumption that color vision, analogous to other types of human behavior, evolved gradually from more primitive vision. From the primitive eye like those of some animals could be secured only sensations of black, white and gray. The theory supposes that there exists in the receptors a chemical substance which when subjected to light of any kind arouses sensations of gray and white. It is assumed that in the primitive eye only this substance existed. In the course of evolution, this "mother" substance in the cones (one type of receptor in the retina) became differentiated into two component substances. By means of stimulation of one of these components, sensations of *blue* are produced while stimulation of the other results in *yellow*. At a later stage of evolution, the *yellow* component became differentiated into two components, stimulation of one resulting in *red*, of the other in *green*.

Let us now, while reviewing some of the facts of vision, see how the Ladd-Franklin theory explains them. Six primary visual sensations were found introspectively; namely, white, black, red, yellow, green and blue. All of these appear in the theory. The theory affords plausible explanation of the relative frequency of Red-Green color blindness; the stage of vision being more recent it is more likely to fail to appear in particular persons. The totally color blind—who is very rare—has only the primitive visual substances. The facts of complementary colors are also accounted for. When the complementary blue and yellow lights enter the eye at once, both of the component substances derived from gray are activated. To arouse both components of gray is to arouse gray itself, which is exactly what happens. For the same reason, when red and green stimuli simultaneously enter the eye, the result should be a yellow sensation since red and green are the components of yellow. This is true to the facts. Blue is now required to mix with yellow to produce gray, therefore the complement of red must be a mixture of both green and blue, that is, green-blue, and the complement of green must be a blue-red, that is, a purple. These were exactly the facts mentioned above under color-mixing. By providing as the immediate stimulus for vision certain rather complex chemical activities, a basis for explaining after-sensations is provided since the chemical activities may persist after the removal of the external stimulus. The theory, then, explains very well many of the known facts of vision.

Sensations of Hearing.

The Auditory Stimuli.—The auditory stimuli, like the visual, are waves; they are often called sound waves as the visible waves are called light waves. Sound waves

are not movements in the ether but in the air. The vibration rate of audible (or sound) waves varies from about 12 to 50,000 or less.

Auditory Sensations: Tones and Noise.—Between rates of 12 and 50,000 vibrations per second is a continuous series of single rates which may affect the ear singly or in numberless combinations, just as light waves may, singly or in combination, affect the eye. Very rarely do we find a single wave acting alone; the stimulus is nearly always a combination but it is quite usual for one wave to be predominant. A few special instruments, notably tuning forks, when constructed with greatest care, will give very nearly, if not quite, a single vibration rate. The sensation aroused by waves all of the same vibration rate is called a *pure tone.* Unless you have heard one of the rare instruments mentioned, you have never experienced a pure tone.

A pure tone varies in two ways: in *intensity* or *loudness* which depends upon the force of the air vibrations and in *pitch* which depends on the particular rate of the vibrations.

Pitch.—The tone of a sound is determined by the vibration rate of the air wave. In the case of pure or single vibration rates, the tone of the sound is the same as the *pitch;* that is, the *pitch* fully accounts for the tone. Pitch varies from the lowest produced by a vibration of 12 per second or thereabouts, depending on the individual, to the highest, produced by vibrations of 30,000 to 50,000—there are great differences between the highest audible pitch for different persons. Between these extremes, the average individual can distinguish 10,000 to 11,000 different pitches or tones, some more, some many less. All musical sounds may be reduced to these pure tones. But before considering how familiar

sounds are made up of combinations of pure tones, let us ask whether all of these tones may be reduced to a small number of primary qualities as the pure colors were reduced to four color qualities.

The Primary Tone Qualities.—The task of discerning in the thousands of pure tones a number of primary qualities from which others may be derived has been baffling. There seems to be in the tonal scale no fixed points of reference, no clearly distinctive qualities, which the intervening tones clearly resemble, comparable to the primary colors of the color circle. Tones at intervals of an octave—that is, such tones as the several C's in the music scale—have been suggested as primary because they are more alike than the intermediate tones. In other systems of music, Chinese for example, the octave, however, is not fundamental and the confusion of octave notes is not so striking. It must be said, then, that primary tone qualities comparable with primary color qualities either do not exist or at least have not been isolated.

Because pure tones are so many and unclassifiable, most of us are not well acquainted with them as individuals. Take middle C, a tone produced by a vibration rate of about 260, the standard of the keyboard. Most people cannot identify it and still fewer could hum it without first hearing it. By the age of 5 years the average child can recognize and name a number of common colors; but as adults we have no such speaking acquaintance with particular tones.

Timbre.—Few tones are pure; most of them, such as those produced by musical instruments, are due not exclusively to wave lengths of a single rate, i.e., to one pure tone, but to several in which one predominates. Most musical tones, then, are impure due to the presence of

waves other than those of the predominating tone. These additional waves produce the *timbre* of the note.

The predominating rate gives the pitch. Thus middle C on the piano, violin and cornet have the same pitch due to the predominance of one vibration rate of about 260 but they have different *timbres* due to differences in the supplementary vibrations. As the mixture becomes very complex, we call the sound *noise,* but even the noises commonly experienced have a pitch, which means that they have some vibration rate more or less predominant. If you scratch the cover of this book slowly, then more and more quickly, you will get noises increasing in pitch. If you strike at once a large number of piano keys at one end, then at the other, both give noise of different pitch. Noises merge with tones; home made xylophones, steam whistles and some "jazz bands" are midway between the two.

The Composition of the Timbre of Musical Instruments.—The sound waves produced by each of the favorite musical instruments, at least most of those found in the western world, are many but they are mainly related to each other in a simple way. Usually the instrument gives one tone predominating in various degrees called the *fundamental,* and others, the *overtones,* whose vibration rates are simple multiples of the rate of the fundamental. The overtones, in other words, are pure tones one or more octaves above the fundamental. The flute, for example, gives one of the simplest combinations of the musical instruments; a strong fundamental, and relatively faint overtones of the first, second, and sometimes very dimly, higher octaves. Waves from the piano are very complex, having, compared to most instruments, a relatively weak fundamental, and sometimes as many as 42 overtones, which vary greatly in

intensity. Well trained musicians are able to single out some of these overtones and hear them singly; but most of us hear merely fundamentals differing in quality or timbre. In sounds produced by musical instruments, the "quality"—strictly speaking, the *timbre*—is due to the number, kind and intensity of the overtones. An instrument like the violin will produce at any pitch a number of different overtone combinations. It is in this production of appropriate timbre that the master's touch differs from that of the novice.

Comparison of Auditory and Visual Sensations.—A comparison of auditory and visual sensations reveals both similarities and differences. Saturated colors correspond to pure tones; the merging of pure colors with gray resembles the merging of pure tones with noise. The number of discriminable sensations among saturated colors is small compared to the number of discernible pure tones. Pure colors and pure tones are both unusual; the predominating stimulus is usually mixed with others. Saturated colors, unlike pure tones, may be reduced to a small number of elements which, properly mixed, yield all others as blends. As a consequence, results of color stimuli applied simultaneously to the eye are different from the results of mixing sound waves. Red and yellow stimuli give a single sensation, orange, in which resemblance to both red and yellow appear. Two sound waves similarly mixed yield not a single sensation which is intermediate and a thing unto itself, but a blend of another sort in which both tones appear and may be distinguished as such. They harmonize rather than blend. The facts of complementary color stimuli, in which two stimuli combined produce an entirely different sensation from either alone, has no exact equivalent in hearing. Some sounds will not blend. They conflict and produce

a throbbing or rasping effect but they never neutralize each other. In general, a particular sound stimulus produces its particular sensation more invariably than do particular light waves produce theirs. Different sounds may harmonize or conflict but they never so completely lose their individuality as do colors. There are positive after-sensations, that is, the continuation of the sensation after the stimulus has been removed but for such a brief period that it can barely be detected. There is nothing in sound comparable to the negative after-sensations in vision. Adaptation is not found in hearing as it is found in vision, taste and smell. One can learn to disregard sounds such as the ticking of the clock or the roar of the street, but this is an acquired habit and not a phenomenon of the sense organ. In vision, it is usually assumed that some subtle chemical activities in the retina account for adaptation and after-sensations, but in hearing no such chemical reactions are assumed to intervene between external stimulus and the arousal of nerve impulses in the receptors. The receptors are presumably aroused by mechanical stimulation, but exactly how is as yet unknown.

Sensations from the Skin.

Many distinguishable sensations may be aroused by stimulating the skin in various ways, such as by touching lightly or heavily with tufts of cotton, blunt or sharp instruments, metals of various temperatures, by rubbing the surface lightly or heavily with rough, smooth or sharp objects, scratching, piercing, tickling, by applying electric currents, acids and chemicals, etc. Such stimuli result in many sensations for which we have names—tingling, itching, tickle, burning, scalding, impressions of roughness, moistness, stickiness and others. Introspective

study has shown most of these experiences to be compounds of a small number of elementary sensation-qualities.

The primary sensation-qualities almost universally accepted are four: *coolness, warmth, pain* and *pressure.* Some authorities believe that *touch* and *tickle,* which would be included above under *pressure,* are distinctive and elementary. According to these investigators the qualities from the skin, then, are six: *coolness, warmth, pain, pressure, touch* and *tickle.* According to the six quality classifications, pressure refers to a somewhat vague sensation aroused when an object is placed on or against the skin. Compared to touch, as when the skin is lightly touched with a dull pencil point, pressure is felt as more dull and deep. Tickle is aroused by drawing a light bristle across the back of the hand, especially if contacts are made with hairs.

Since the several receptors are scattered fairly generously over the skin—but by no means uniformly—many objects or conditions may arouse several of them at once. Pulling a piece of plaster stuck on the skin arouses various pressure receptors, possibly warm or cold and pain, especially if a hair is pulled slightly. Moistness is due to the combined stimulation of pressure and cold. Itch is due to a combination of touch, tickle and mild pain; certain stinging sensations combine touch, pain and warmth; in a sharp sting pain predominates. Many "skin sensations" then are compound sensations.

Pressure, warmth, and cold show adaptation effects, but pain does not. One may become quite insensitive in a brief time to warmth and cold, to pressure, as of clothes, or to odors, but not to pain. One may, of course, neglect a pain, but when one turns attention to it, the sensation is still there. When odors or colors have

become weak through adaptation, they cannot be greatly increased in this way. Severe pains seem to become no less severe as they continue. On the whole, this persistent call for action is to the advantage of the organism since pain usually is a symptom of harmful influences.

Sensations from the Muscles.

The muscles are supplied with receptors that are normally aroused by movements and pressures. The ligaments and joint surfaces also have receptors that are stimulated by muscular activities. Compounds of sensations aroused by stimulation of these receptors constitute the "muscle sense." They are usually called kinesthetic sensations, which means literally sensations depending upon movement. Under usual circumstances these sensations are rather vague. They are, however, of great importance since upon these sense organs muscular activity largely depends. Destruction of them would tremendously disturb writing, speech, and management of the body generally. Combined with pressure on the skin, the muscle sense makes possible the judgment of weight as in hefting an object. Muscle sensations from the eye are of great importance in the judgment of the distance, size and shape of objects seen.

Sensations from the Organs of Equilibrium.

Closely related in function to the sense organs in the muscles are those in the organs of equilibrium adjoining the inner ear. They are stimulated by movements of a liquid which follow any movement of the head. What one senses is bodily movement, as when one is turned on a piano stool, is lifted or lowered in an elevator or is moved in a train. These sense organs are essential to the maintenance of bodily equilibrium in all bodily move-

ments as in standing in a train, sitting on a merry-go-round and in walking, stooping, or jumping. Excessive stimulation as in spinning on a piano stool or sailing on rough water brings out the sensations more clearly and results in after-sensations which may be readily observed. The elementary qualities are like those of sensed bodily movements. When extreme these sensations constitute a complex called giddiness or dizziness.

Sensations from the Inner Organs of the Body: Organic Sensations.

Hunger, thirst, nausea, faintness, feverishness, fullness, heartburn, headache, stomach-ache, back-ache, palpitations, shivers, and pains—griping, cutting, burning, shooting, throbbing—are but samples from a long list of sensations aroused by mechanical, thermal and chemical stimuli of sense organs in the body. The anatomy of the internal receptors is not very far advanced nor is the introspective analysis of the organic sensation-qualities. Introspective study is hampered by the difficult and in most instances total impossibility of applying experimentally the stimuli as they occur under natural conditions. The experimenter cannot produce a shooting pain in the chest or feverishness of the sort or at the time wanted. Introspective study has revealed the qualities of pressure, warmth, coolness and pain, at least. Some investigators believe that all of the complex organic sensations experienced contain no qualities other than these. The differences perceived are believed to be due to the character of the combinations of these qualities, the intensities of each in the combinations, the number and location of the receptors aroused and the temporal order of the stimuli. The total effects may differ greatly because of the differences other than those in sensation-

qualities. Other investigators believe that there are at least several genuinely different pain-qualities; some add *ache* as irreducible to pain and some add other unique organic qualities. Only future research will disclose the facts.

The inadequacy of the analysis of organic qualities is regrettable not only because a better understanding would be important in applied science, especially in medical diagnosis, but also because it would greatly increase the possibilities of comprehending human behavior in general. Were our knowledge more adequate, the task of interpreting the nature of feelings, emotions, impulses, and desires; of explaining the acquisition of skills; of diagnosing the bases of temperament, mood and personality would be less difficult and speculative.

Summary Concerning Sensations.

Sensations are conscious reactions which arise when certain stimuli affect the sense organ in such a way as to arouse a nerve impulse. Only the conscious reactions aroused in this way are called sensations. Study of sensations has been directed to the identification and analysis of the qualities of the reactions and the correlation of the response with the stimulus. In some instances, notably in vision, a given sensation-quality may be produced by several different external stimuli; in others, notably in hearing, the given reaction is normally produced by only one kind of stimulus. The phenomena of adaptation, contrast effects, positive and negative after-sensations reveal other peculiarities of the relations of external stimuli to conscious reactions.

In some instances, the many distinguishable sensations produced by the stimulation of a given type of sense organ have been reduced by introspective study to a

small number of primary or elementary sensation-qualities; in other instances such analysis has been less successful. The analyses of tastes into four qualities, sweet, sour, salt and bitter; of visual sensation into six qualities, red, yellow, green, blue, black and white, are probably the most satisfactory. Sounds have been studied extensively but it has not been found possible to reduce them to a small number of sensation-qualities comparable to the color-qualities. Sensations from the skin were once accepted as reducible to four qualities, warmth, coolness, pain and pressure, but recent work indicates that pressure should, perhaps, be subdivided into pressure, touch and tickle. Kinesthetic sensations aroused by movements have been usually attributed to pressure alone or coupled with dull pain; sensations resulting from stimulation of the organs of equilibrium have qualities similar to the pressure of kinesthetic sensations. It is recognized that the muscle sense merits further study. The organic sensations especially have been incompletely investigated mainly because of the intrinsic difficulties encountered. The elementary qualities found are at least pressure, pain, warm and cold, but possibly there are several kinds of pressure-like and pain-like qualities.

Feelings.

It is now apparent that many experiences commonly called "feelings" are really simple sensation-qualities or blends of such qualities. To "feel" cold, hot, hungry or tired or to "feel" a pain, a cramp and many other internal conditions is to experience sensations singly or in complex combinations. Feeling, then, in popular usage refers to many conscious experiences that are really sensations. In psychology, however, the term has been reserved to apply to certain conscious processes that have been held

to differ from sensations. In its technical usage the term feeling refers to conscious processes that are to be sharply distinguished from sensations.

Wundt's Six Feelings.—That there are certain conscious experiences with qualities radically unlike those of sensations has been held, by some investigators at least, since the first years of systematic work in introspective psychology. William Wundt, often termed the "Father" of modern psychology, proposed six different feelings, all of which he considered to be elementary, irreducible qualities different from the qualities of any known sensations. The six feelings were: strain, relaxation, excitement, calm, pleasantness and unpleasantness. The tendency, since the time of Wundt's pioneer work, has been to reduce the number of elementary feelings. It is now quite universally agreed that strain, relaxation, excitement and calm are really complex blends of organic and kinesthetic sensations just as hunger and fatigue are. The only experiences now defended as elementary qualities different from sensation-qualities are pleasantness and unpleasantness. There are, moreover, about as many who believe that these experiences are blends of organic sensations as of those who believe they are distinctive. We shall consider briefly both sides of the issue, but first we must try to indicate what is meant by pleasantness and unpleasantness.

Pleasantness and Unpleasantness Contrasted with Certain Sensations.—What are technically defined as feelings must be distinguished from certain sensations which they may accompany or follow. Unpleasantness is often confused with sensory pain. Pain is a definite type of sensation-quality occasioned by the stimulation of a particular kind of sense organ. Unpleasantness, although it usually accompanies pain, is not identical with it. Pain

may be at times pleasant as when a boy gently moves a sore tooth. In pathological cases, extreme sensory pain seems to be distinctly pleasant although it is still pain. Just as unpleasantness usually accompanies pain, it usually, but not invariably, accompanies bitter, certain odors, pressures, giddiness and other sensory compounds. In these instances the unpleasantness is clearly distinct from pain. Pleasantness similarly usually accompanies other sensory experiences such as sweet, mild, sour or salt, many odors, colors, pressures and sounds. Pleasantness does not invariably go with these experiences, however. When one is satiated, sweet may be unpleasant; when one is nauseated, the odor of fruit may be unpleasant; when one is tired, otherwise pleasant voices may be displeasing. The feelings, then, while they may accompany any sensory experience are not identical with any of these here mentioned.

It is difficult to describe the two types of alleged feelings. One can understand them only by examining the conscious experiences which arise when one is aware of the pleasantness which usually accompanies a sweet taste and the unpleasantness which accompanies a bitter taste or the pleasing experience produced by a musical instrument as contrasted with the unpleasantness produced by a noise, or the agreeableness which accompanies flattering remarks as compared to the disagreeableness which is often a consequence of reproof.

Physical Basis of Pleasantness and Unpleasantness Unknown.—The uncertainty concerning the character of pleasantness and unpleasantness is mainly due to the fact that the exact physical bases of both are totally unknown. We do not know what parts of the brain are active nor do we know what neurones in the midbrain or cord, if any, are specifically involved. No specific sense

organs of a unique character which, when stimulated, result in pleasantness or unpleasantness have ever been discovered and no groups of internal receptors of the kinds already described are known to be invariably stimulated during these experiences. Whether the two feelings, then, are essentially different from organic sensations is a problem for introspective study. Concerning the physical bases of feelings there is nothing to offer but hypotheses designed to harmonize with the findings of introspection.

The Evidence of Introspection Concerning Pleasantness and Unpleasantness.—On the first question, namely, whether pleasantness and unpleasantness are similar to other blends of organic and kinesthetic sensations, opinions differ. The majority of investigators believe there is a considerable resemblance; that these feelings, like tingling excitement, or mild organic discomfort, may reasonably be assumed to be complex blends of organic sensations. Some investigators, however, insist that pleasantness and unpleasantness are utterly unlike any organic sensations and maintain that they are primary and irreducible conscious qualities of another order. This first point, then, is disputed but on some others better agreement has been secured.

(1) The feelings are, compared to most sensations, very unstable and variable, when studied attentively. Attend to a red color and it reaches maximum clearness; attend to a toothache and it seems more intense, but attend to the feeling of pleasantness or unpleasantness itself, and it is likely to fade away. This fact may mean, however, that the moment you attend to the feeling, the stimulus which aroused the feelings has been neglected so that the feeling disappears. In other words, it is easier to attend to colors or pressures because one can prolong

the stimulus. Feelings, like many organic sensations, cannot always be aroused or prolonged when you want them. (2) Feelings are not localized in any particular place as most tastes, colors, odors, pains, etc., are. They are felt as in us some place, but in no particular place. Some observers report, however, that their location is diffuse but no more diffuse than general malaise or excitement or organic irritation which are accepted as organic sensations. (3) Another significant observation is that pleasantness and unpleasantness never appear at the same time. One may have neither; he may feel indifferent but he cannot feel pleasantness and unpleasantness simultaneously. The two are opposites and mutually exclusive. (4) The final fact from introspective study is that neither feeling appears by itself but always as an accompaniment of some other process, sensation, emotion, thought. Pleasantness and unpleasantness are therefore often spoken of as forming the "feeling-tone" of a sensation or the "background" of other experiences. Rival hypotheses concerning feelings should take into account these four facts from introspective study.

Most of the particular theories concerning feelings fall into two general types as earlier suggested. We shall offer one example of each type.

The Theory That Feelings Depend upon Conditions in the Neurones.—Those writers who favor the view that feelings are not blends of sensations but unique conscious experiences usually explain them in terms of some condition in the neurones which are called into action. It is assumed that activity of the neurones when they are in one kind of condition results in pleasantness, and when in another kind of condition, in unpleasantness. Since the inner conditions cannot be of two kinds at once, the feeling is certain to be one or the other unless the con-

dition is midway, when the "feeling-tone" presumably would be indifferent. Since the inner conditions of the neurones concerned in some response, such as tasting food, could change, according to the theory, it would be possible to account for the reaction being tinged with pleasantness on one occasion and indifference or unpleasantness on another. The feeling as thus explained may require no special sense organs or brain areas since they are due to the action of any cortical neurones; any sensation, perception, emotion or idea may be tinged with pleasantness or its opposite. The theory, therefore, harmonizes very well with the facts concerning the feelings adduced from introspective study.

The main difficulty with the theory is that the nature of the "conditions of the neurones" is unknown and not easy to imagine. Some writers have associated pleasantness with easy and free running brain action, while unpleasantness goes with slow, impeded action. This notion is clearly erroneous inasmuch as unpleasant responses, as to a sting or piercing sound, are exceptionally quick. Other writers suggest that well-nourished brain cells produce pleasantness when called into action whereas poorly-nourished cells when forced to act produce unpleasantness. There is no reason for believing, however, that the cells concerned in producing sensations of pain or bitter are less well nourished than those concerned in sweet or blue. Other suggestions have been made but most of them are too vague to permit the application of a test. The theory as a whole should not be discarded, however, because the physical nature of the neural conditions underlying pleasantness and unpleasantness is unknown. It may at any time be discovered.

Theory That Feelings Are Blends of Organic Sensations.—To account for the several facts concerning

pleasantness and unpleasantness which introspective study has revealed, the writers who uphold the opinion that these two feelings are blends of sensations must assume that each is the result of a particular organic change set up by some stimulus. According to this theory, the stimulus, say a complex sound wave, produces not only a sensation of noise but also a certain complex organic change in the body. This organic change now arouses the receptors in the organs concerned and the nerve impulses thus actuated, on reaching the brain, arouse a complex of sensations. This blend of sensations is the feeling. It is the combination of organic sensations aroused indirectly by a cycle of stimuli and responses. The feeling must necessarily lag behind the sensation but probably by an almost or quite imperceptible time. The theory, furthermore, assumes two combinations of organic changes which are antagonistic and mutually exclusive. One group of changes produces the blend of sensations termed pleasantness; the other, unpleasantness. A sweet taste usually is immediately followed by inner changes of the first sort, a bitter taste by changes of the second sort. The thought of a friendly act arouses the changes which result in pleasantness while the thought of a harsh rebuke arouses the unpleasant type. According to this type of theory, both pleasantness and unpleasantness are blends of sensation-qualities.

This is a very attractive theory and one which seems to be gaining in favor. The difficulty with the hypothesis is that the existence of two mutually exclusive types of organic changes which go with pleasantness and unpleasantness exactly and exclusively have not been discovered. Although the specific organic reactions underlying the two feelings are unknown this fact does not constitute

disproof of the general theory. Our knowledge of inner responses is meagre.

The Function of Pleasantness and Unpleasantness.—While the physical basis of the processes is unknown, pleasantness and unpleasantness are nearly universally recognized as among the fundamental native reactions of the organism. Many experiences are accompanied by pleasantness, others by unpleasantness, because of our original nature. As William James writes: "Why does a hen, for example, submit herself to the tedium of incubating such a fearfully uninteresting set of objects as a nestful of eggs? Why do men always lie down, when they can, on soft beds rather than hard floors? Why do they sit round the stove on a cold day? Why do they prefer saddle of mutton and champagne to hard-tack and ditch water? Why does a maiden interest the youth so that everything about her seems more important and significant than anything else in the world? Nothing more can be said than that these are human ways and that every creature likes his own ways."

In general, those experiences which are accompanied by pleasantness are beneficial for the organism; those which produce unpleasantness are harmful. There will be many particular exceptions; our native organization is not equipped to meet perfectly all the situations of varied lives. Much is left to learning and our native tendencies to be satisfied and annoyed are greatly modified by experience. Some things originally distasteful we learn to like; other things natively pleasant we learn to dislike. But to many situations we instinctively react in one way or the other and the majority of cases the pleasant reactions are biologically serviceable. In this fact lies the function of the feelings.

Pleasantness and unpleasantness are correlated each

with a fundamental attitude of the organism. Pleasantness goes with the positive attitude of acceptance, acquiescence or following up; unpleasantness goes with the negative attitude of recoil, rejecting or avoidance. The situation which arouses pleasantness is the one which we remain with and perhaps deal with further; the situation which produces unpleasantness we seek to avoid or escape. Pleasantness is a conscious state which stands as a sign of situations to approach and react to further, unpleasantness stands as a sign of situations with which to have no further dealing unless to avoid or remove them. The two feelings, then, are intimately linked up with two fundamental forms of bodily adjustment, positive and negative. As such they play a significant rôle in reactions in general and in the process of habit formation as we shall see later in detail.

QUESTIONS AND EXERCISES

1. Make a list of events or forces in or outside the body to which we are insensitive.
2. Can you suggest any convenient classifications of the sensations? For example, classify sensations in accordance with the origin of the stimulus, whether internal or external. What difficulties are encountered? Suggest other types of classification.
3. Explain the facts that (a) certain light waves on the hand give a sensation of warm, whereas the same rays on the retina give the sensation of red; (b) soap in the eye gives pain, whereas on the hand it feels merely moist and slippery.
4. Which sense is described in this quotation: "In its own field its chief characteristic is the clearness and precision of its data. Beside it the other senses are dull and groping.—It is a long range sense,—it is a sense that serves readily, though indirectly, for other senses;—it is a sense that usually carries attention with it." (From E. C. Sanford, *Amer. Journal of Psychol.*, 1912, p. 65.)
5. Which sense is here suggested: "It is a sense that once stood

high, but is relatively unimportant; it might be wholly lost with small inconvenience though perhaps with some loss of pleasure."

6. A motion picture is really a series of discrete pictures, yet the picture seems continuous. How is this fact explained? Compare with the operation of a color wheel using a disc half white and half black. Do these two sensations fuse at all speeds? If not, what is the minimum rate?
7. With what color would you surround each of the following to intensify its saturation: green, yellow, red, brown, black, pink.
8. According to the Ladd-Franklin theory could a person be color blind to red only?
9. Why is one able to see in daylight from the bottom of a well stars which cannot be seen from the surface of the ground?
10. How do you distinguish the voices of different people? Explain in technical terms such as are used in the book.
11. Explore the skin with blunt metals, warm, hot, cool and cold, with a stiff bristle, a sharp needle, and the frayed end of a bit of cotton twine. Try to identify the different sensory experiences, particularly the different types of tactile qualities. Do you think tickle is merely an instance of pressure? Are there two or more varieties of touch or pressure?
12. If a coin is pressed against the forehead of a blindfolded subject for 20 seconds and then removed, he will probably continue to sense the coin. What phenomenon is here illustrated?
13. In what ways may vision serve practically as a substitute for smell; in what respects would the substitute be inadequate?
14. Carefully distinguish between the sensation and the feeling. If you *like* sweet and dislike bitter, are you dealing with sensations exclusively or are feelings involved?
15. What senses produce the most enjoyable experiences? What senses have the greatest æsthetic values? Why are some senses sometimes called the "higher" senses? Which are they, and why should they be so termed?
16. Grade the following experiences, on a scale for pleasantness in which the most extreme pleasantness is called 10, the most extreme unpleasantness —10, a neutral state 0.

    Burning the hand
    Eating an olive
    Smelling whisky
    Smelling coffee

Hearing a loud conversation while trying to sleep
Missing a street car
Being told that you are very attractive

In which of the ratings do you agree most closely with others; in which least closely? Why?

GENERAL REFERENCES

Nearly all psychology texts give comprehensive accounts of the topics treated in this chapter. A fair sampling of the whole field may be obtained from these four: W. B. Pillsbury, *Essentials of Psychology,* New York: Macmillan, second edition, 1920; E. B. Titchener, *A Beginner's Psychology,* New York: Macmillan, second edition, 1920, R. S. Woodworth, *Psychology,* New York: Henry Holt, 1921, and Knight Dunlap, *Elements of Scientific Psychology,* St. Louis: C. V. Mosby, 1922.

Books devoted entirely to a special phase of this field are: J. H. Parsons, *An Introduction to the Study of Colour Vision,* Cambridge University Press, 1915; R. M. Ogden, *Hearing,* New York: Harcourt Brace, 1924; H. L. Hollingworth and A. T. Poffenberger, *The Sense of Taste,* Boston: Moffat, Yard, 1917; Hans Henning, *Der Geruch,* Leipzig: Barth, 1916, the substance of which is given in an article by E. A. M. Gamble, "The Psychology of Taste and Smell," *Psychological Bulletin,* 1922, pp. 297-306.

CHAPTER VII

THE EMOTIONS

The discussion of sensations, especially the organic sensations and the feelings, completed in the preceding chapter, paves the way for a treatment of emotions. Such experiences as thirst, dizziness, fullness, faintness, nausea, feverishness, widespread discomfort and the like are found to be complex blends of organic, kinesthetic and skin sensations. These sensations are aroused by various mechanical, chemical and thermal stimuli affecting receptors in the body or on its surface. In some instances, as, perhaps, in hunger, the area of stimulation is small; in others, as in fever, the area is widespread. The body is well supplied with sense organs and sensory nerves by means of which the inner changes or reactions of the body may be sensed. That is to say: sensations may be aroused by the organism's own activities; we may sense our reactions as well as the stimuli which arouse them. The feelings, pleasantness and unpleasantness, are according to one theory, complex blends of sensations aroused by some type of inner changes. The emotions, according to a famous theory, the James-Lange Theory, are also compounds of sensations produced by profound changes in the body.

The James-Lange Theory of Emotions.

By emotions we mean such experiences as love, hate, fear, jealousy, joy, anger, sorrow. Emotions we recognize

as subjective, as due to conditions in us. According to observations first reported, simultaneously by William James and Carl Lange, more than thirty years ago, the emotions are produced by an extensive group of changes in the body, in blood vessels, intestinal muscles, in glands, in fact, in nearly all of the bodily mechanisms. The inner changes which underlie the emotions are severe enough to stimulate innumerable sense organs in the skin, in the inner linings of the body, in the walls of blood vessels, in the muscles and other organs. This widespread stimulation results in a veritable flood of sensations due to the torrent of nerve impulses flowing in from all parts of the body. This complex of sensations, according to James and Lange, *is the emotion.* This view is now known as the James-Lange Theory of Emotions.

Emotions Contrasted with Other Blends of Sensations.—Note that emotion, as a psychological term, refers to the state of consciousness; that is, to the complex of sensations and not to the bodily activities themselves. Almost every stimulus to which we react mentally arouses skeletal and inner responses to some degree, although the organic reverberation may be very slight in many cases. If to a subject comfortably seated, slight odors, tastes, tactual stimuli, or meaningful words are presented, very delicate instruments will record slight changes in respiration, blood pressure, glandular activities and the tonus of skeletal muscles. But these bodily changes are often too slight to become vividly conscious; the subject is unaware or barely aware of their existence. Only those bodily changes which are rather vividly felt are called emotions.

The term emotion, however, is not applied to the feeling of relatively simple or readily localized activities such as hunger, thirst, the burning or gnawing of indigestion,

nausea, suffocation, or palpitation of the heart; nor do we speak of a single type of bodily sensation, however diffuse, such as general muscular fatigue, fever, or chills as an emotion, although the latter are approximations. No, the genuine emotions, such as fear and rage, are much more diffuse, mixed, unanalyzable groups of sensations than any of these. They represent changes which pervade the whole body, and among them the smooth muscle and glandular changes which are controlled by the autonomic nervous system are most conspicuous. In fact, unless an experience posesses a considerable organic reverberation—strained or irregular breathing, palpitations of the heart, flushings and palings, quivers, sinking feelings in the stomach, tensions of the arteries, and other changes especially in the viscera—we do not speak of the mental state as an emotion at all. The sensations found in emotions come from changes in sense organs, and skeletal muscles as well as the internal changes, however, and with these outward visible "expressions" we shall deal first.

The Outward "Expressions" of the Emotion.

We recognize general bodily postures that are characteristic of certain emotions: we speak of being rigid with fear, bent with grief, or puffed up with pride. The expressions of the emotions appear more uniformly in patterns of response of the facial muscles. That many of them have an instinctive basis is suggested by the fact that they are, so far as may be observed, universal and fairly constant reactions. If the reader will observe the plates (Figure 50, Chapter XIII) he will be able to identify most of the emotions "expressed," although the face is unfamiliar, and much, such as color and movement, is lacking.

The emotional expressions may serve the purpose of influencing the behavior of other organisms. The display of teeth, and other angry expressions along with hissing, growling, barking, etc., may be conceived as instinctive forms of "bluffing" which may frighten off smaller or less courageous opponents. Note the transformation in size and ferociousness of appearance of a cat when menaced by a strange dog. Similarly the human expressions of derision, scorn, disgust may modify the acts of others. Smiling, or a "sad expression," although the origin is obscure, invite kindly and sympathetic behavior. The erect, puffed-up attitude of pride may beget admiration or submission.

The wide-open eyes in wonder or surprise are an adjustment which provides a wide range of vision. The narrowed eyes in anger are a kind of visual concentration on the object of attack, while the puckering of brow and closing of lids serve to protect these vital organs from injury. The slowing of breathing, in the first stages of fear, provides for more adequate hearing. Sniffing and pricking up of the ears in animals are sensory adjustments to slight stimulation. Much of the expression of an emotion, then, is the result of sensory adjustments.

Gritting and display of the teeth in anger among animals are motor adjustments for attack. Humans, under primitive conditions, may have used their teeth as weapons; the tenseness of muscles about the jaw is a result probably of these adjustments. The widened nostrils in fear or anger permit more effective breathing; clenching the fists and other muscular tensions have obvious utility. The bristling of hair about the neck and other preparatory reactions of animals belong here too. The turning aside and wry face in disgust probably originated in the infant's response to undesired food or to

noxious odors. The expressions under emotion, then, are in part the results of adjustments for motor response to the exciting object.

The outward expressions of the emotions, depending mainly on the patterns of response among the skeletal muscles, large and small, show an almost unlimited variety. Figure 50 (Chapter XIII) gives only a small sampling of the many facial expressions which this one subject made. Patterns of general bodily adjustments brought about by different stimuli are also very numerous. This fact will appear to be of considerable importance later in attempting to disclose the bases of an alleged large number of different emotions. It will be found that while the skeletal "expressions" are numerous and distinctive the types of visceral responses, depending on the smooth muscles and glands, are very few.

The Nerve Control of the Internal Emotional Changes.

The internal changes which seem to provide the major portion of the sensations that constitute the emotion are under the control of the *autonomic system*. The nerves of this system, connected through synapses with motor fibres which issue from the spinal cord and brain stem, are subject to nerve impulses received from the central nervous system. By means of inborn connections, the organic activities may be accelerated or retarded by pains, noises, odors, or other forms of external stimuli.

The autonomic system is divided into three groups of nerves:

1. *The cranial division,* connected with the upper part of the cord and mid-brain.

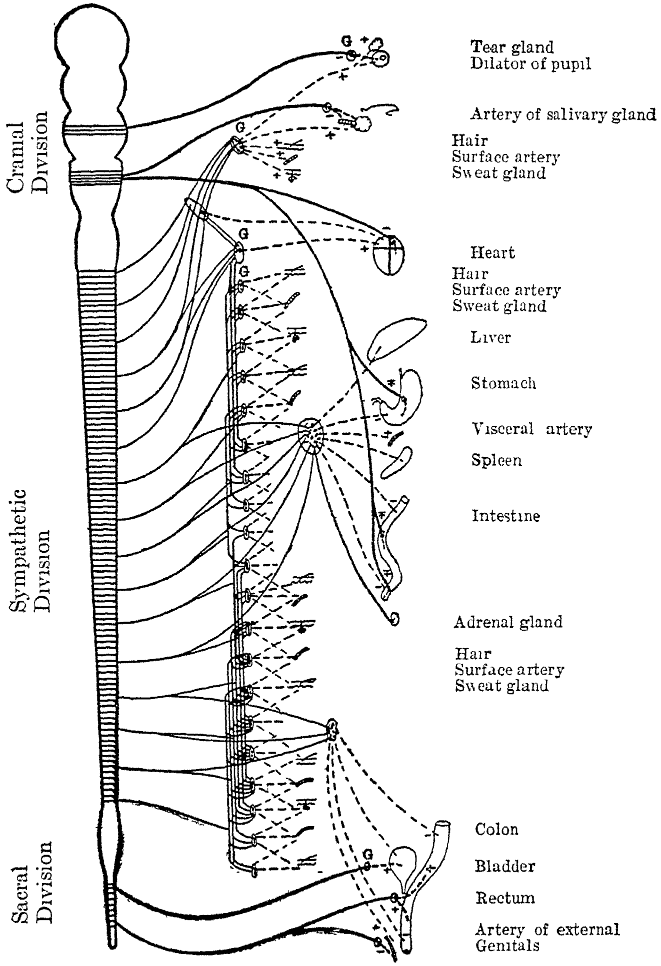


FIG. 31.—DIAGRAM OF THE AUTONOMIC NERVOUS SYSTEM. The brain, mid-brain and spinal cord are indicated at the left. The solid lines running outward from the brain and cord represent the preganglionic neurones. The dash lines are the autonomic fibres running from the ganglia to the inner organs. Note that the middle or *sympathetic* division has connections with all the organs represented; that the *cranial* division has connections with organs in the upper part of the body, the *sacral* in the lower. A + mark on the organ indicates an augmenting effect of the nearby fibre, a — mark indicates a depressive or inhibiting effect. The *sympathetic* is antagonistic in function to the *cranial* and *sacral* divisions. (From W. B. Cannon, *Bodily Changes in Pain, Hunger and Rage,* by permission of D. Appleton & Co.)

2. *The sacral division,* connected with the lower part of the cord.
3. *The sympathetic division,* connected with the intermediate part of the cord.

The cranial and sacral divisions, although supplying different regions, have a similar function which is always antagonistic to the function of the sympathetic. The cranial division depresses the activity of the heart, whereas the sympathetic stimulates it to greater activity. The cranial increases the glandular and muscular activities of digestion in the upper, and the sacral in the lower part of the intestines, whereas the sympathetic diminishes these activities in both regions. In general, if the cranial or sacral division accelerates, the sympathetic depresses; if the former inhibits, the latter stimulates; that is, they are antagonistic.

Since the divisions of the autonomic bring about different internal reactions, the emotional states which go with them must be distinctive. This, in fact, is the case; the sympathetic is involved in the strong emotions of which fear and anger are the best examples; the cranial and part of the sacral division go with mild, pleasant states, such as general bodily comfort and pleasure; while part of the sacral is concerned in lust and sex excitement.

The sympathetic system, although tremendously complex, embracing nerves discharging into nearly all of the smooth muscle and glandular mechanisms, acts very much as a unit. The innervations may be slight or profound but in either case the effects are widespread. The cranial and sacral divisions do not act invariably as units; they permit of specific innervations of the different bodily organs.

Internal Changes in Fear, Anger, and Similar Emotions.—Marked changes in the digestive and assimilative

functions are brought about by innervations of the sympathetic system which occur in fear and anger. If a cat which has been fed a meal of gruel containing bismuth, a substance opaque to x-rays, is placed before the screen of a fluoroscope, the normal rhythmic, churning movements of the stomach may be clearly observed. If the cat is angered by a barking dog, these movements may be greatly diminished; in fact, they often cease altogether. Even in milder vexation, such as that produced by tying a small stick to the cat's leg, the stomach movements may be inhibited. The glandular activities of digestion are similarly diminished. In a typical experiment on an angered dog, instead of the usual 65 or 70 cubic centimeters of gastric juice, an amount less than 9 cubic centimeters (and this of poor quality) was secreted. Thus the whole digestive process is side-tracked.

What purpose could all of this serve? None is very apparent save this—the elimination of the work of digestion liberates a good deal of energy that may be otherwise utilized. That such energy is conserved for strenuous muscular action is probable.

With anger or fear go also pronounced circulatory changes due to sympathetic discharge. The heart beats more rapidly and with greater amplitude. The arteries of the abdomen are constricted, thus driving large amounts of blood to other parts of the body, mainly to the skin, skeletal muscles, brain, and lungs. The constriction of arteries, together with increased heart action, produces a higher blood pressure and more effective circulation through the organs involved in bodily action.

The lungs are stimulated to greater activity; breathing becomes deeper and more rapid. Sweat breaks out on the skin, making an early start toward the elimination of heat from the body engaged in strenuous exertion.

The sympathetic fibres also activate the adrenal glands whose secretion, adrenalin, poured into the rapidly circulating blood promptly reaches the various bodily organs and profoundly affects many of them.

Like the impulses of the sympathetic system, adrenalin diminishes the glandular and muscular activities of digestion, constricts the abdominal arteries, and stimulates the heart and lungs. It increases and prolongs the more prompt effects of the sympathetic nerves and produces several additional changes. Reaching the lungs, adrenalin causes a dilation of small smooth muscles, which permits more ready ventilation, and thus provides for a more speedy assimilation of oxygen and discharge of the products of fatigue. Adrenalin has a specific effect on skeletal muscles, greatly increasing their sensitivity to nerve impulses, which results in greater strength and endurance. Adrenalin causes the liver to pour into the blood more rapidly its store of blood sugar, the fuel which is burned in muscular work; it also causes the liver to secrete a substance which makes blood clot more rapidly on reaching the air, thus reducing the flow in case of an injury.

The Emergency Theory of the Emotions.

Other organic changes, characteristic of fear and anger, could be mentioned; but this, at least, is already apparent —the body is adjusted during such emotions to provide for the greatest muscular strength and endurance. On the basis of this fact, an American physiologist, W. B. Cannon, has framed what he calls *The Emergency Theory of the Emotions.* The sympathetic system is conceived as an elaborate check and drive mechanism that is thrown into gear by events which demand immediate and energetic action; that is, by emergencies. Under primitive

conditions, loud or sudden sounds, the perception of wild beasts, unfamiliar men, obstinate obstructions, and other objects or conditions which arouse fear or anger, represent situations in which physical strength and endurance, as in the fight or flight, may enable the organism to survive. It matters relatively little that digestion is inhibited, the heart or lungs overworked, if the animal successfully meets the emergency.

The organic responses, then, are preparatory reactions —elaborate mobilizations for violent and prolonged physical action. The emotions of fear and anger, as conscious states, are, in the main, the sensations occasioned by these inner changes.

General Types of Emotions.

The sympathetic system, it was said, is antagonistic to the functions of the cranial and sacral autonomic. Innervations of the latter tend in general to promote the quiet, normal organic processes of digestion, assimilation and excretion—the quiet service of building up bodily resources. Stimulation of certain nerves of the cranial division increases the flow of saliva and gastric secretions, dilates the blood vessels of the viscera and promotes the action and tone of the stomach and alimentary canal. Other nerves of this division slow the heart, thus resting the cardiac muscles. Certain nerves of the sacral division are concerned with the proper regulation of the bladder and the lower alimentary canal.

Innervation of the visceral organs by the cranial and sacral nerves tends to arouse quiet, pleasurable emotional states for which we have but few names. A comfortable state of "well-being" is about all there is to it at times; and the mild emotions of mirth, of pleasure in hearing music, of joy in one's work, in agreeable conversation,

comradeship or surrounding, harmonize with the upbuilding internal services of the body. These we shall call the mild joyful emotions. Under such mild but joyful mental states we are best fitted for most of the tasks of daily life.

A portion of the sacral division of the autonomic system is concerned with stimulation of the sex functions. Such stimulation activates a number of muscular and glandular functions, in various degrees of intensity, which result in a complex of vivid sensations. These sensations are the primary factors in certain experiences of an emotion-like character that we shall call the *sex emotion.*

The Three Types of Emotions.—Three general types of inner responses have been found. Each furnishes in all probability the fundamental basis of an emotional experience. The three types are:

1. The strong, "emergency emotions," depending on the discharge of the sympathetic division of the autonomic system. Since the sympathetic divisions act as a whole, such emotions must be organically much alike. They may, however, differ in degree from very slight to very great intensity.
2. The mild, joyful, upbuilding emotions, depending on the activity of the sacral and cranial division of the autonomic nervous system. The sensations thus provided are usually mild and inconspicuous. Since they arise from the normal healthful bodily functions they are often not thought of as emotions at all. We shall refer to them, however, as the mildly joyful emotions.
3. The sex emotions, including lust, depending on certain activities of the sacral system. Presumably there are several types of sex sensation-complexes. Some of them vary in degree from slight to great intensity.

Aside, then, from the sex emotions and the mild, pleasurable states of well-being which go with the action of nerves in the cranial and sacral autonomic, all other genuine emotions, so far as is known, result from innervations of the sympathetic system.

Subdivisions of the "Emergency" Emotions.—We are at present unable to give subdivisions of either the mild pleasurable emotions or the sex emotions. The emotions which are known to go with sympathetic action may, however, be listed in several groups. Since we shall be mainly concerned with these, a fourfold classification is presented.

1. Anger, and other similar states, such as rage, fury, vexation, irritation, revenge, and perhaps jealousy and scorn.
2. Fear, and similar states, such as dread, anxiety, worry, melancholy, terror and perhaps grief and regret.
3. Excitement, shock, uneasiness, nervousness, embarrassment.
4. Extreme pity, sympathy, elation, enthusiasm.

Anger and Fear.—It is assumed that the several states which are classified with anger, *i.e.*, rage, vexation, etc., are more like each other than they are like fear or any of the states similar to fear. It is not assumed, however, that the experiences in the anger-like group are wholly unlike those in the fear-like group. What, then, are the precise similarities and differences?

All of those inner changes brought about by the action of the sympathetic system are to the best of our knowledge essentially the same except for differences in intensity or degree. The sympathetic system acts as a whole and it acts essentially in the same way in anger, vexation,

jealousy, fear, or anxiety except that there is more intensity in some states than in others. Since the inner changes in smooth muscles and glands are the basis of a very conspicuous part of the complex of sensations which makes up an emotion, all such emotional experiences have much in common. Introspectively, this seems to be the case. The fundamental feature of all these strong emotions is the flood of sensations—a sort of excitement and turmoil—from the smooth muscles and glands.

Most people, however, find the experience of "being afraid" very different from "being angry" or "being excited." Upon what do these differences depend? Being "afraid" or "angry" or "excited" are very complex experiences which include components other than the sensations from functions controlled by the sympathetic system. They include, in the first place, a certain pattern of response of the skeletal musculature. Each has its particular facial expression and its specific arrangement of muscular tensions, inhibitions and relaxations in the hand, arms, trunk, legs, feet. Note the differences in all of these external muscular patterns in men in fear, anger, grief, etc. Each such pattern of motor response arouses a particular complex of sensations; each "feels" different from the other. In part, then, the observed differences between anger, anxiety, fear and the others are due to the variations in the patterns of adjustment of the skeletal muscles. This, however, is not the only difference.

The percepts of the exciting objects differ greatly in the several experiences. In fear, it is perhaps a wild animal; in anger, an annoying intruder; in excitement, a critical audience that is perceived and thought about. The percepts and realizations of these situations; the related memories, anticipations, apprehensions and other ideas tend to fuse with the internal and muscular sensa-

tions. As was pointed out often in preceding sections, fusions of different mental states is the rule; only careful introspective analysis enables us to disentangle them. To these percepts and ideas must be added impulses. And the impulses experienced in different emotional experiences are very unlike. In fear are felt strong impulses to escape; in anger, impulses to attack or injure in some way. These urges are usually vivid during emotional crises and they contribute greatly to differentiating the experiences of "being afraid," from "being angry," etc. These impulses are not, strictly speaking, parts of the emotion. They are components of the total experience at the time but really not a part of the emotion itself.

The organic turmoil which is the main component of the emotion, then, is essentially the same in all strong emotions except lust. The skeletal musculature, sensations from which form a component of the genuine emotion, takes different patterns in various emotions. Fused with these are non-emotional experiences, namely, the percepts, judgments, apprehensions, ideas of all sorts and the urgent impulses which differ greatly in various emotional experiences. Care must be exercised, therefore, to indicate clearly which of the several components of the emotional experience one has in mind during discussion.

Shock and Excitement.—Violent inner shock (which is due to very intense sympathetic innervation) or excitement represents the sheer organic changes very well, since the impulses are often vague and uncertain. Excitement thus resembles both fear and anger organically, but differs from both because of the indefiniteness of the impulsion. For example, a sound heard by a primitive man prowling in the woods might have aroused the sympathetic activities, experienced as excitement or uneasy alertness, until the source is more clearly perceived. If

the stimulating object is found to be a ferocious beast, the percept with the impulse to run, added to the organic and muscular adjustment, constitutes the whole experience of fear; if the stimulus proves to be an old enemy, that percept plus the impulse and a muscular arousal to fight gives us the state of anger. The inner changes themselves, devoid of percepts, ideas, impulses and muscular adjustments, are felt as various degrees of inner turmoil ranging from terrific shock to slight excitement.

Exciting Joy, Enthusiasm, Etc.—The violent or exciting states of mirth, joy, pity, zeal, enthusiasm, and the like are included in the list of emotions which depend upon the activity of the sympathetic system. Suppose, for example, that you are quietly enjoying a concert. If the music becomes very stirring, you may experience a glow, a pang in the breast, a fullness of breathing, a flutter of the heart, a shudder or darting chills, a sinking sensation in the region of the stomach—evidence of the discharge through the sympathetic. Joy, on other occasions, may become so violent as to produce weeping, labored breathing, high blood pressure, and digestive disturbances. Enthusiasm, especially in people of the emotional or excitable type, may become so exciting as to make quiet work or thought impossible. Thus, in the intense, exciting, or violent form, joy, enthusiasm, pity, and others belong in the sympathetic group.

Other Alleged Emotions Are Mental and Motor Attitudes.—In addition to the intense emotions of the exciting type, the sex emotions and the mildly pleasant states which accompany the organic and visceral processes of the normal and upbuilding types, the language abounds with names of conscious states which common usage treats as emotions—wonder, timidity, gratitude,

admiration, suspicion, coyness, pride, hope. How are they to be explained?

The traditional explanation is that these states are compounds or fusions of elementary emotions, fear, anger and others, in much the same way that most complex movements are new, acquired organizations of elementary motor acts, or that a novel perfume is a new fusion of elementary odors. This type of reasoning by analogy is intelligible enough but the facts of the operation of the autonomic system are against it, and, the writer believes, the facts of introspection are also against it. Since the two divisions of the autonomic system are antagonistic, they cannot both operate at the same time. Fusions of certain emotional conditions are thus at once eliminated. The sympathetic system, the indispensable basis of nearly all vivid or exciting emotions (except lust), operates primarily as a whole; it is not subject to differential action, to functioning in various patterns of parts. The theory of acquired emotional complexes, based on analogy, can scarcely maintain itself in the face of such antagonistic facts.

How, then, are these mental states to be explained? Most of them should probably not be considered emotions at all; at least, not emotions in the same category with anger, fear and the others above described. They are mental states embracing impulses, sensations from facial and postural reactions, varying ideas, feelings of pleasantness or unpleasantness more or less pronounced, and other data, relevant or irrelevant, with which consciousness is usually fringed. To illustrate: timidity embraces distinctive impulses of a submissive character, the sensations from a characteristic pattern of facial and bodily muscles, certain intellectual ideas and apprehensions, and the like. In this mild form, the inner turmoil,

characteristic of emotion, is in abeyance. Timidity may be called *an attitude of mind*, or objectively viewed *an attitude of behavior*, but not a full-fledged emotion. Let the object or person producing the attitude of timidity in an observer now appear more dangerous, and timidity may give way to fear, as the impulse to escape couples with a welling of disturbances within the body. Timidity, an attitude, may thus merge with fear, an emotion. Indeed, timidity as an attitude may be accompanied by the typical excitement of sympathetic action, but in such a case we should distinguish the two in scientific thinking as we distinguish odors from real taste in the flavor of a food. Similarly, hope, pride, suspicion and the others are mainly attitudes of mind, typified by characteristic impulses, ideas and facial and bodily postures, feelings of pleasantness or unpleasantness, but not necessarily involving the inner conditions which are the indispensable characteristics of genuine emotions. Only when the internal, visceral disturbances are found do we have a full genuine emotion; often in hope, wonder, etc., this component is nearly or quite indistinct.

Although the visceral components of the emotional experience do not combine into various new patterns, some other elements may. In all likelihood the facial and bodily musculature may form many new patterns. Thus one may acquire an "expression" which is partly like fear and partly like amazement, or a combination of mirth and sorrow, etc. It is questionable whether really different impulses can be compounded in this way. It is possible, however, to shift rapidly from one impulse to another. Most of us, for example, after having observed a dignified gentleman fall in the snow or be otherwise humiliated, feel a curious alternation of the impulse to laugh and the impulse to feel and express regret. One

urge may give way to the other so rapidly that it seems that both are experienced simultaneously. It is unlikely that they do fuse, however. The way in which we suddenly "explode" with mirth during such experiences indicates the sudden giving way of the impulse of pity to the impulse of mirth.

Summary.—The whole emotional experience is obviously complex. The basal organic changes are of three types. Each type is found in many particular emotional experiences. Each type appears in varied levels of intensity but one type will not fuse with others. The skeletal muscle components are of many forms and may recombine into new patterns. The impulses, which are very numerous and different in kind as well as in intensity, shift rapidly but apparently do not fuse. The same is true of the feeling component. It is of two forms, pleasantness or unpleasantness, which may alternate but do not fuse. Difficult as it may be, it is the task of psychology to isolate and describe the characteristics of each of these components. In no other way may the whole experience be made intelligible.

Having selected certain fundamental type emotions and described some of their constituents, we are now ready to consider whether they are native or acquired and if native what situations tend instinctively to produce them.

Are the Emotions Native or Acquired?

Observations of infants soon after birth (by Watson and others) have given convincing evidence of the native character of significant symptoms of typical emotions. Facial expressions, bodily adjustments, changes in breathing and circulation and other characteristics of fear and anger may be evoked almost immediately after birth.

These symptoms indicate sufficiently the arousal of the sympathetic system. In animals, too, the elaborate internal changes appear very early. The emotions depend on complex patterns of response that are fundamental and native. Evidence of joyful experiences also appear very early. They will, therefore, be considered as fundamental and instinctive responses. The sex emotions are not obviously present at birth. Indeed, the glandular mechanisms essential to the profound sexual emotions are not functioning completely until pubescence. That the inner adjustments which form the main components of these emotions are acquired is altogether unlikely. They show a complexity of coördination that seems intelligible only when conceived—like fear, anger and joy—as instinctive.

Situations Which Instinctively Arouse Fear and Anger.—The machinery of the main emotions and the coördinated character of its operation in each case are native, but what situations instinctively activate these remarkably complex reactions? A complete answer to this question cannot be given at present. *Fear* (according to Watson) occurs in infants as a response to:

1. Sudden removal of support, as when the hands are withdrawn, allowing the infant to drop a few inches before being caught.
2. A sudden push or shake or movement of blankets, etc., when the infant is sleepy.
3. Loud sounds.

When greater maturity is reached, probably other stimuli instinctively arouse fear but the evidence is not complete. It is believed (by Thorndike) that at appropriate periods in life each of the following alone, or in at least in combination with other factors, arouses fear:

thunder-storms and other loud noises, solitude, darkness, being suddenly brushed or clutched, strange persons of unfriendly mien, large animals approaching one, reptiles and certain vermin. Very young infants betray no instinctive fear of animals. Whether the fright which makes its appearance later is the result of animal stories or other experiences or due to the ripening of a delayed instinctive tendency is not as yet certain. Essentially the same uncertainty prevails concerning some of the other sources of fear.

Anger is a reaction that seems to be instinctively aroused by a very large number of stimuli. It was found (by Watson) that the infant is angered by almost any persistent hampering of his movements, even by "slight constraints put upon the head by soft pads." As the child grows older, it seems natively disposed to become angry whenever any activity under way—eating, sleeping, sitting still in thought, walking, etc.—is persistently interrupted or interfered with. Being slapped or otherwise pained, being shoved or seized, are types of interferences that are specially likely to arouse anger from the earliest stages of infancy.

The situations which arouse fear and anger in the main represent *emergencies*. Under conditions of primitive life these emotions were activated instinctively by conditions in contending with which increased bodily strength and endurance would be of great utility. Mankind today possesses the same emotional equipment that thousands of years ago helped its ancestors to survive. At least, modern biology tells us that the physical, emotional and mental equipment of people today is almost imperceptibly different from that of mankind ten or twenty thousand years ago. The emergency theory of the emotions gains support both from a consideration

of its survival value in the race and from the study of the native responses of infants of today.

Situations Which Instinctively Arouse Joyful Emotions.—Joyful emotions of the mildest sort accompany the smooth running, undisturbed bodily processes. They are the result of sensations produced by such organic functioning. They may be heightened in infants by such stimuli as feeding when hungry, removing from a hard to a soft bed, warming up when cold and by certain tickling, shaking, rocking, patting, turning about and other forms of attention. Among adults enjoyment results from innumerable situations but it has not been possible to distinguish the native from the acquired sources.

Laughter, the clearest objective symptom of a joyful emotion in most children and adults, has been the subject of many volumes of speculation but as yet no satisfactory account of the essential factors which produce it at any time has been produced. Many native sources of joyful emotions remain obscure. This much seems clear, however, perfect operations of the cranial-sacral functions, that is, fine digestion, assimilation, etc., result in a strong predisposition toward joyfulness and laughter. The child well fed, healthy, functioning excellently, laughs and is joyful for almost no reason at all.

The Sex Emotions.—Some students (*e.g.*, Freud and Watson) have concluded that the joyful emotions and the sex emotions are really the same. Usually such students assume that all forms of joyful emotions are really sexual in character. This notion seems to be incorrect. Everyday experiences and introspective study will disclose unique characteristics of forms of mirth, laughing, joyfulness and bodily exuberance that are unlike lust or any form of sex emotion. The sexual functions, moreover,

are controlled by fibres of the autonomic system which may act independently of the other fibres of the sacral and cranial division. These are sufficient reasons for treating the joyful and the sexual as distinct emotions.

The only way of arousing, instinctively, the sex emotions is the stimulation of certain erogenous zones. It is maintained by some that a specific sex emotion may be thus aroused in infancy but this is doubtful. Certainly a complete sexual emotion cannot be aroused until pubescence and, then, most readily, when the organic condition is favorable. Lust, among adults, may be aroused in innumerable ways as may fear, anger, or joy, but by situations whose connection with the emotion is acquired. How emotions, themselves native and instinctively aroused by relatively few situations, become attached to new stimuli will be disclosed in Chapter XI.

Of the three general classes of emotions, most is known about those which depend on the action of the sympathetic system. Since these are of great significance in everyday life, some attention will be given to them in their relation to motor and mental efficiency, to health and to other conditions.

Some Effects of Fear, Anger and Similar Emotions.

Fear, anger and the other emotions of this class, controlled by the sympathetic system, are preparatory reactions in the form of mobilizations of organic and visceral resources for the maximum physical exertion. Under conditions of primitive life in the jungle, their utility in contending with human or animal enemies, with storms, floods and natural forces would be apparent. In modern life, they may be of service in similar exigencies, but ordinarily they begin and end without the physical exertion for which they are a preparation. We

are often angry but seldom fight; often fearful, without flight.

On Health.—What are the results of emotions, such as rage, anxiety or fear, when they are not accompanied or followed by physical exertion? Indigestion is one result. The angered cat showed stagnation of food in the stomach from three to six hours on different occasions. Among humans anger, excitement, sorrow, and extreme joy are often followed by more or less severe digestive disturbances. Loss of appetite and weight under prolonged sorrow, anxiety, or worry is often observed. The blood sugar liberated by the liver when not utilized as muscular fuel is partly wasted by excretion through the kidneys. The general wear and tear on the heart and arteries, the adrenal and other organs which are driven to excessive action during the strong emotions, may in the long run be injurious. At least, it is widely believed that the excitement, worry, fear, anger, and irritations of life hasten the breakdown of the visceral functions and it is well known that diseases or deficiencies of these functions are greatly aggravated by emotional disturbances.

When asked on his 89th birthday for the secret of his longevity and vigor, Charles W. Eliot, President Emeritus of Harvard University, is reported to have said: "My experience does not furnish a short, explicit prescription of keeping health and working power till eighty-nine. I will say, however, one thing seems highly important—*keep as calm under all circumstances as your nature permits.*"

On Skill, Thought and Ability to Learn.—However greatly crude strength may be increased under the strong emotions—anger, fear, or excitement—efficiency in acts of skill, in judgment and reasoning, and in learning is decreased. The excited or angered baseball player

fumbles the ball. The frightened youth forgets his "piece." An inventory of the experiences of skilled musicians disclosed an almost universal conviction that any exciting emotion aroused by the audience, or even an emotion normally aroused by the music itself, is detrimental to proficiency. Even in boxing, where strength assuredly counts, it is well known that skill is disrupted by rage. In golf, tennis, and other sports requiring great precision, the disastrous effects of anger, chagrin, nervousness, and anxiety are patent.

Thinking, reasoning, judgment are, like skill, disturbed by the strong emotions. In melancholy, ordinary tasks or debts look herculean. Frightened by a cry of "Fire!" the audience falls into an irrational panic; the drowning man strangles the swimmer who attempts to rescue him. Even for murder, the leniency of the jury is generally assured if the act was committed in a passion. Violent emotions represent, in effect, internal preparations for violent acts, and often the less intense grief, fear, vexation, or excitement may lead to thoughts, words, or acts that seem unwarranted or ridiculous in calmer moments. In laboratory studies, although violent emotions are seldom secured, the general tendency of the milder ones to disturb acts of thought or skill appears clearly. Such tasks as tracing the outline of a pattern which is observed only by reflection from a mirror (mirror-drawing) or performing a difficult feat in mental arithmetic are retarded and sometimes disrupted by vexation, anger, chagrin, anxiety, or even by too exciting enthusiasm. It is characteristic of the novice to be subject to frequent emotional upsets. As the learning progresses, greater poise is achieved. Generally speaking, the highly efficient performance is characterized by a quiet alertness and unemotional zeal rather than by excitement or emo-

tional enthusiasm. There are, however, many mental and motor functions such as writing, simple arithmetic, etc., so well habituated as to withstand very considerable emotional disturbances.

On Stimulating Activity.—The notion that the strong emotions in the routine of life render a tremendous service by providing impulsion to greater accomplishment, that they represent the release of hidden springs of energy, is likely to be very misleading. That they do provide a temporary increase in muscular strength we have seen, but this is attained at no small cost nor can it be long maintained. The athlete may run his quarter mile better if excited (although many prefer to be calm), but if he is "on edge" too long before the race, he may be half exhausted before it begins. The depleting effects of a public performance by the uninitiated, of a frightful or grievous experience, are familiar to all. "What," asks David Belasco, "would be the condition of a player who, every night for even one week, should really feel all of the emotions of Hamlet or Othello or Lear; of Queen Margaret or Lady Macbeth or Juliet?"

But is the strong emotion not of great utility as an occasional upheaval to arouse us out of complacency to fresh resolution and determination, to set the ball rolling? If a student feels he is losing his interest in his studies—going stale—would not the part of wisdom be to arouse somehow in himself profound disgust, or anger at his lethargy, or vivid excitement by anticipation of the rewards of greater achievement? It would seem so; and perhaps the answer would be affirmative if there were no better ways. The physician often faces a similar situation. The patient reports bodily sluggishness and loss of grip. While pills or stimulants may be prescribed, the physician knows they are but temporary expedients which

work no permanent cure. The remedy lies not in drugs but in better hygiene; better habits of eating, sleeping, work and play. The remedy for mental inertia is not in emotional stimulation but in improved habits of mental hygiene. A strong emotion, acting like a drug (for adrenalin and other glandular secretions are drugs), has the habit-forming effects of such artificial stimulation. If we rely upon coffee to keep us awake, shortly coffee is required in increasing doses. If we rely this week on emotional outbursts to get us at our tasks we shall the more surely require them the next. The emotional upheaval is like a drug, strictly an emergency measure, to be used only as a last resort, and then advisedly.

Must One Experience an Emotion in Order to Act It?—Admitting that the strong emotions are not essential but usually detrimental to the achievements of modern life, are they not essential to certain tasks, such as pleading in court, preaching, and other public performances? Could one make a stirring address or, what would seem to be more difficult, could one portray an emotion without really experiencing it himself? The testimony of great actors and actresses should furnish an answer to this question.

Many years ago, William James collected the statements of a number of leading actors and actresses and found a division of opinion. Many of the greatest were able to portray perfectly the outward appearance of emotions in face, posture, gait, and voice without the visceral and organic accompaniments on which the emotion chiefly depends. Others believed they were unable to affect the dissociation so completely. The few cases, however (if they are correct observations), are enough to show that the inner turmoil is not essential to successful dramatization.

David Belasco, the eminent theatrical producer, has a decided opinion on the matter. "To assert that any actor must or even can really feel, when acting, all that he represents—assuming, of course, that he is representing any vital or even vivid emotional experience—is merely to maintain what is manifestly nonsensical. In acting, there never can be, in the very nature of things, any real feeling. . . . Nowhere are complete self-control, dominion, poise more absolutely essential to success than they are in acting and they cannot exist where sensibility is permitted to hold sway."

Mr. Belasco cites a number of anecdotes in support of his belief that great actors, even in playing profoundly emotional rôles, really maintain perfect self-control. For example: "One night when playing Othello in America, Salvini, as he spoke the final words, 'no way but this, killing myself to die upon a kiss,' and collapsed in his appalling simulation of death, murmured to Miss Viola Allen, the player of Desdemona: 'For the one hundred and third and last time this season!' "

The Need of Control of the Emotions.—While it is possible, as actors and actresses testify, to portray the facial, bodily, and vocal features of an emotion without the inner turmoil, the more frequent modification in every-day life is the elimination of the outer expression, while the internal disturbances hold sway. We experience anger, fear, or sympathy without obvious motor response. Indeed, the emotions may come to be highly satisfying, as in the case of the few who greedily study the daily paper for fresh incentives to grieve idly at the world's sufferings, rage at its vices, and exult at its achievements without contributing in any way to the relief of suffering, to the abolition of vice, or to the increase of achievement. The emotions might be defended

on the ground that they are intensely satisfying, that they add to the color and variety of life and break up the drab monotony of routine. It would be a sorry world for most of us were there no indignation, exaltation, or excitement; even fear, anger, and grief—under certain circumstances—are satisfying. If we can experience these emotions with little likelihood of serious consequences, as we may enjoy fear in a storm-tossed ship if assured of safety, or anger and grief from scenes on the stage or screen, it is undeniably pleasant, as our willingness to pay substantial prices for these experiences amply attests. What is needed, of course, is temperance and wise control. The main dangers lie in the possibilities of permitting emotional enjoyment to become debauchery or a substitute for action. Not only are worthy impulses and attitudes with less internal turmoil more desirable from the standpoint of personal efficiency and health, but the world is better served by acts of relieving suffering, and resisting oppression than by reactions which begin and end wholly in one's breast.

General Emotionality.

Individuals differ in their general emotional responsiveness. At the one extreme are the calm, stolid, imperturbable individuals; at the other the excitable, sensitive and easily aroused; and from one extreme to the other we pass through degrees of emotionality insensibly minute.

The concept of general emotionality is not unlike the concept of general athletic ability, general strength, or general mental ability. Two people at approximately the same stage of emotionality are not necessarily identical, but are like two people of about the same general athletic

ability, who are alike only on the average, while different, more or less, in each of many particular forms of athletic prowess. Averaging up the emotional reactions to many situations, we arrive at a rough central tendency and it is to this that the term general emotionality refers. The cases of great general emotional susceptibility, or of great emotional lethargy, need not represent a particular lack or deficiency in one's equipment nor some added defect, native or acquired, but merely the extremes of a group of tendencies possessed by all.

Emotional Excess.—An excess of emotionality is the main characteristic of one extreme. All or nearly all emotion may be excited by stimuli, numerous and slight, more than is the case with average people; joy, fear, sorrow, melancholy, and excitement are easily and frequently aroused. Not only are emotions easily and often aroused, but they are usually intense; joy is for them often explosive and riotous, anger becomes violent rage, sorrow becomes intense grief.

While there are individuals predominantly sorrowful, or mirthful, or easily angered or affrighted, the more typical case is the individual who is susceptible to all or nearly all forms of emotional response. As a general rule, the child readily susceptible to one form of emotion is readily susceptible to others. The child who laughs the heartiest, most readily breaks into tears; adults capable of the most enraptured pleasure are susceptible to the deepest sorrow or the most exquisite pain. The most readily enraged may be, in turn, the most compassionate; the most ferocious, the most fearful. The sympathetic system, in all of these cases, seems to be hypersensitive and hyperactive; easily thrown into gear and unusually intense in its response to stimuli of many sorts.

Emotional Instability.—Generally, but not invariably, extreme emotional sensitivity is characterized not only by emotional excess but also by emotional instability. The emotional child often shifts abruptly from laughter to tears, from affection to anger, from self-confidence to pessimism. In this fickleness, the emotional sensitivity and excessiveness of response can usually be recognized, despite the fact that other types of instability, more mental than emotional in character, making up what is called the "psychopathic" or the "neurotic" constitution, are frequently found in the same individual. Indeed, excessive emotionality and nervous and mental instability are often difficult to distinguish. Of the latter, something will be said in the next chapter.

The extremely unemotional individual is less easy to detect and his behavior is a less serious matter with the exception of the infrequent cases caused by actual disease. The least emotional individuals are by no means unemotional, but are aroused less frequently and less intensely. The mechanism of the emotions, designed for emergencies, is rather easily aroused even in those relatively unresponsive. It is the over-emotional rather than the under-emotional who experience difficulties in adaptation to modern conditions.

In the emotional child the sympathetic nervous system, it would appear, is readily innervated, bringing about the train of visceral changes previously described. How serious these disturbances may be depends, of course, upon the soundness of the organs themselves; but indigestion and intestinal disorders, disturbances of circulation and of heart action, nervousness, insomnia, general weakness, and fatigability are frequently found. With the internal activities of the body more fully at the mercy of the external conditions, more than ordinary

care and prudence must be exercised to avoid overtaxation of reserves. The emotionally unstable child usually cannot indefinitely keep pace with those of greater poise but otherwise of equal endowment.

Handicaps Produced by General Emotionality.—In the work of the school, the handicap of excessive emotionality usually becomes apparent. Pupils of high mental abilities who are otherwise sound, except that they are very emotional, experience difficulties in holding themselves down to continuous, especially monotonous, work. Drill in spelling, arithmetic, phonics, and writing is carried on sporadically. In the formal aspects of these subjects, the emotional child lags behind his intellectual possibilities. He lacks the capacity for steadiness and persistence of concentration which such functions demand. His attention flags and shifts before the lesson is well under way. Special interests, more individual attention, shorter periods of practice with frequent change, an abundance of physical freedom, and other special forms of treatment frequently enable the emotional child to make greater achievements.

In the work of adult life, excessive emotionality is a handicap in a similar way. Tedious and monotonous work is trying and may be unusually fatiguing. Fast, exciting, exacting or dangerous tasks also exhaust the bodily reserves more rapidly than in less emotional natures. Special occasions or exigencies—examinations, disappointments, misfortunes—are abnormally disrupting and require more rest for recuperation. In sum, excessive sensitivity of the sympathetic system is a handicap demanding special management and hygiene as much as deficiencies of the lungs or muscles or heart.

QUESTIONS AND EXERCISES

1. One of the main issues raised in the text is the question as to whether there are many different emotions, as some have asserted, or only a few real emotions, as the author states, other so-called emotions being really complex states of mind in which the genuinely emotional component may or may not be present. Attempt introspectively to test these opposing views. During a period of several days, record introspective accounts of fears, angers, shocks, excitement, etc., experienced attempting to distinguish between the percepts, ideas, impulses, muscular attitudes and inner excitement. Which of these vary the most?
2. Observe an infant or a child who is experiencing some emotion. Describe the facial and bodily movements, and other "expressions." In what respects are they preparatory reactions, and how do they affect the behavior of others?
3. Can you offer any evidence in favor of the statement that grief, melancholy, anger, or fear are sometimes satisfying?
4. Is it wise to give way to an emotion when you feel the impulse?
5. How often does the average adult experience fear under the conditions of modern life? List some of the situations which provoke fear. Do the same with anger.
6. Can you think of situations, under modern conditions, wherein a strong emotion would be of utility?
7. What are some of the impulses which you have experienced when angry or frightened?
8. Were there cases in which the impulses changed while the emotion remained the same? Can you cite cases in which the emotion changed while the impulse remained the same?
9. Give samples of "irrational" fears, angers, melancholias, etc.
10. What emotions, chiefly, arise when you are physically tired, tired by mental work, hungry, or in states of illness, indigestion, uncertainty?
11. What people are, as a rule, more emotional; successful or unsuccessful, intelligent or dull, educated or uneducated? Who have the more irrational emotions? Who have the stronger emotions?
12. Is there any likelihood that an average person can learn to control his emotions completely? Why are we likely to be deceived in judging emotions and impulses from facial expressions of a temporary character? Of a permanent character?
13. Just what is meant by "general emotionality?" Arrange ten

people of your acquaintance in order from the most to the least emotional. Are there also differences in susceptibility to particular emotions?

14. Can you trace in your own experience or that of others the gradual development of habits of emotional expression, such as habits of "feeling blue," of being easily irritated, of persistent cheerfulness? Can you find cases of developing habits of "crying it out" when one is emotional?
15. How does the fact that children and adults are often easily upset when performing before an audience bear upon the discussions of the emotions? What emotions does an audience usually arouse?
16. Give, in your own words, the substance of the James-Lange theory of emotions. Cite evidence in favor or in opposition to it? What kind of experiment can you suggest which might yield crucial evidence?
17. In what respects does the autonomic nervous system differ from the central nervous system? In what respects is the former subordinate to the latter?
18. The following experiment will provide interesting and useful data concerning your emotional life, especially if it is done by all the members of a class, thus providing results for comparison. Every night during a week record the emotional experiences of the day. (It is better to take only one emotion such as fear or anger, for observation at a time.) Grade the intensity of the emotion from 1 (very mild) through 3 (average) to 5 (very intense). Record the situation which provoked it; the time of day; the physical condition at the time, *i.e.*, fatigue, hunger, etc.; the mental condition, *i.e.*, cheerful, worried, etc., the length of time the emotion lasted; its main characteristics as introspectively or retrospectively determined; the impulses accompanying it, *i.e.*, what you felt like doing. At the end of the week summarize the data and compare with others in the class. (The results of two such studies, one on anger and one on fear among college women, will be found in G. S. Gates' forthcoming articles in *Journal of Experimental Psychology*.

GENERAL REFERENCES

The James-Lange theory of the emotions is described by James in his *Principles of Psychology*, vol. II, chapter 25, and by Lange

in an article entitled "The Emotions, a Psychological Study," which has been reprinted with James' chapter in a book, *The Emotions,* forming vol. I of *The Psychology Classics,* edited by Knight Dunlap, published by Williams and Wilkins Company, Baltimore, 1922.

The emotional expressions of animals are best described in Darwin, *Expressions of the Emotions in Man and Animals,* 1872. A suggestive treatment of theories concerning the origin and significance of facial expressions in emotions and in other mental states will be found in F. A. Allport's *Social Psychology,* Boston: Houghton Mifflin, 1924, Chapter 9.

For a description of the autonomic nervous system and a discussion of the internal changes during emotions, see W. B. Cannon, *Bodily Changes in Pain, Hunger, Fear and Rage,* New York: D. Appleton, 1915.

For a defense of the unity of sexual and joyful emotions see J. B. Watson, *Psychology,* Chap. 6; for a defense of combined or derived emotions see R. S. Woodworth, *Psychology,* Chap. 7, or W. McDougall, *Outlines of Psychology,* Chap. 11.

CHAPTER VIII

THE DOMINANT HUMAN URGES

We have now considered several types of significant reactions, namely, muscular reactions, sensations, feelings and emotions. Most of the reactions previously considered are influenced in some degree by types of urges or craving which are active at times. Whether sensations or other experiences are pleasant or unpleasant depends upon the nature of the cravings then in force. Under the impulse to secure rest, to be permitted to rest is pleasant, to be forced to remain active is unpleasant; during the craving for food, to eat is satisfying, to remain hungry is annoying. In the chapter on emotions we found that the organic conditions which underlie these conscious experiences are closely linked with impulses; indeed, the internal changes may be considered to be an inner preparation to assist in putting the impulses into effect. Anger, to illustrate, usually goes with an impulse to do damage and the visceral changes which underlie the emotions are preparation for vigorous action. In the chapter on instinctive motor reactions we found that man inherits relatively few ready-made skills of a complex sort but a vast assortment of elementary and loosely organized muscular responses out of which innumerable coördinated acts are built up through learning. From the earliest days of life the child begins to strive to acquire habits, some of which are so complex as to require years in the making. Why form such skills? Behind the habits that men form, behind all the activi-

ties and strivings which result in the acquisition of habits and skills, we may find impulses, urges or cravings of some sort. To these dynamic factors in human conduct the present chapter will be devoted. It will deal with the factors which initiate and sustain and variously condition human action.

The human organism, even in infancy, is decidedly active and its activity usually appears to be not altogether random and purposeless but directed toward some end. Our problems are: What are these ends that are sought? What are the sources of the seeking? What are the forces that give human activity, everywhere and so far as we know, at all times, a certain typically human character? Are the directions which human strivings take wholly the results of reasoned choice or intelligent determination or do some or all of them result from urges that are blind or obscure? Even if we are able to foresee or if, at least, we attempt to foresee, the immediate consequences of our daily endeavors, may it not be that unsuspected cravings, native or acquired, are the subtle determining forces? These are some of the questions we must seek to answer.

Theories Concerning Human Springs of Action

At the very outset it must be admitted that the facts concerning the springs of human action have by no means been wholly disclosed. Uncertainty abounds; and as a consequence, differences in opinion prevail. Two extreme positions will indicate the range within which various views may be found.

Freud's View: A Single Motive Force "Libido."—According to one view, that of Freud, founder of the certain school of "Psycho-Analysis," there exists in mankind but one craving or motive force which plays any

considerable rôle in guiding conduct and in initiating activity. This is a craving of a sexual character termed "libido." At the bottom of nearly everything that man does, feels, thinks or dreams is the subtle operation of this elemental urge. The popularity that has been achieved by this view bears testimony both of the possibility that a strong urge may influence action in a surprisingly widespread way and of the difficulty that may be expected in isolating the irreducible or primary human urges.

James' View: Innumerable Impulses.—In contrast with the view of Freud is the older view of James, still maintained by some students, that instead of one or a few urges, man is born with innumerable impulses which are the main sources of action. He states that "every instinct is an impulse" and that "man has a far greater variety of such impulses than any lower animal." By an instinct he means "the faculty of acting in such a way as to produce certain ends,—without previous education in the performance." "Instincts," James adds, "are implanted for the sake of giving rise to habits." Since "many instincts ripen at a certain age and then fade away in all pedagogy the great thing is to strike while the iron is hot, and to seize the wave of the pupil's interest in each successive subject before the ebb has come, so that knowledge may be got and a habit of skill acquired. If a boy grows up alone at the age of games and sports, and learns neither to play ball, nor row nor sail, nor ride, nor skate, nor fish, nor shoot, probably he will be sedentary to the end of his days; and, though the best of opportunities be afforded him for learning these things later, it is a hundred to one bet he will pass them by and shrink back from the effort of taking those necessary first steps the prospects of which at an earlier

age would have filled him with delight. In each of us a saturation-point is reached in all these things"; and we "live on what we learned when our interest was fresh and instinctive."

According to James, instead of one and only one impulse holding sway from the beginning to the end of life, we experience innumerable instinctive urges, each for a time, long or short. These native impulses are the mainsprings of action, the dominant motives in habit formation. Some of the native impulses are supplemented by habit formation and thus become permanent possessions, ever serving to initiate some form of action, others like impulses to hunt, if given no exercise at the time they are active, may gradually die of disuse. But, presumably, the genesis of action is to be sought in the instincts which comprise an "enormous number of special adjustments (which) animals—possess ready-made in anticipation of the outer things among which (they) are to dwell."

Both Views Probably Extreme.—Neither of these extreme views seems acceptable. It is generally held by students of the subject that Freud has erred in failing to perceive other urges such as to satisfy hunger or thirst, which are as potent and insistent as sex, and that perhaps because of his zealousness in maintaining his theory, he has imagined the functioning of "libido" in activities where it did not exist at all. He has, however, done a worthy service in suggesting the subtleness with which a native impulse may work and the wide degree to which its influence may pervade human life.

In the theory of James, it appears that the number of instincts, *i.e.* "the special adjustments—ready-made in anticipation of the outer things among which (we) are to dwell," has been over-estimated. As we saw in

Chapter V the number of native patterns of response in man is probably less than in some animals.

The true account of human dynamic forces probably lies between the two extremes represented by Freud and James. Such an account we shall try to sketch briefly, beginning with a statement of the main suppositions which will be more fully explained and illustrated later.

The assumption is that mankind has, compared to the animals, a smaller number of ready-made, hard-and-fast hereditary motor adjustments each elicited exclusively by particular situations. But, while he has relatively few native reactions fitted to particular things "as locks are fitted to their doors," man does have by nature a very large number of loosely organized motor activities, some or all of which may be brought to bear to secure any particular end—to shake off a human antagonist, to remove an inanimate obstacle, to struggle for a bit of food or a mate. The human repertoire of action may, in whole or part, be called into play under the impulsion of each of several urges. The urges or cravings, in other words, rather than the fixed motor activities, are the primary matters. They are probably more numerous than the cravings of other animals. Man has more diverse and more numerous urges but fewer ready-made methods of satisfying them. Much of his learning is directed toward the acquisition of activities which satisfy his wants. The hypothesis is, then, that the springs of human action are to be found in a number of impulses or urges, some of which are native.

Characteristics of the Impulses and Urges.

Before undertaking an inventory of the dominant human urges, an illustration of the nature and dynamic function of a typical sample may be given.

The Urge of Hunger.—The urge to secure food when hungry which has been studied in infants, adults and animals (by Wada) portrays the several features of a characteristic human impulsion. First, there must be a stimulus of some sort to arouse the urge. *The craving is not a condition which appears mysteriously; it is a definite reaction produced by a stimulus.* In the case of the urge to secure food, the stimulus is a complex of internal conditions of which one invariable symptom is a certain state of muscular activity in the upper part of the stomach. For this urge it happens that there is a particular name, hunger. Hunger, itself a response, is impulsive in character; it is clearly an urge directed toward an end, namely the eating of food. When the urge comes on, the subject usually becomes restless; infants begin to squirm in their cribs, turn the face about, move the lips, and if these seeking activities are to no avail, crying may ensue. Adults engaged in sedentary work, are likely to rise and move about; if asleep, they may twist and turn, often waking. Animals, which like infants, have not acquired habits of directing their attention from the hunger urges, become restless, then actively begin to strive to secure food. If the end reaction, the eating, is long delayed the urge is accompanied by an unpleasant feeling as any man will assert when dinner is late. Animals and infants under sharp delayed hunger will become violently active. Unsatisfied urges, then, are usually unpleasant and highly productive of action, of strivings for relief. To secure the ends to which the urge directs—the eating of food in this instance—is satisfying and the restless yearning subsides.

The Dynamic Rôle of the Urge.—While there are certain interesting facts concerning the things infants and animals instinctively do when activated by the food

seeking urge, such as the native ways of picking up, carrying to the mouth, sucking or chews; ways of spitting or letting drool out when fed, the more important psychological factor is the craving itself and the way in which it motivates activity. Hunger is a powerful urge which persists as long as life and health. It is certainly a craving extensive in its influence on behavior and learning. That it is continually at work in the life of animals is obvious and among men, despite our efforts to reduce its effects by adopting careful and regular habits of relief, it may still influence our lives profoundly. It dictates or interferes with the daily ordering of our tasks, it may influence our choice of residence or wife, it may be a motive, subtle and unsuspected, in actions which range from the choice of newspapers to the conquest of nations. How great the ramifications, how indirect the expressions of the food seeking urge has never been fully disclosed.

Urges Important Factors in Determining Human Conduct.—An urge is conceived to be a form of adjustment which is a reaction aroused by some inner condition of the body or by some external situation or both. Human activity and learning is believed to be in considerable measure initiated and sustained by such urges. Beneath many of our acts one or several cravings may be found. Life may be largely directed, wisely or unwisely, toward the relief of a number of dominant urges. To ascertain how numerous these main yearnings are and whether the ones found are native or acquired are the problems before us.

The Use of the Terms, Urge, Impulse, Etc.—There are many varieties of impulsive activities and various terms applied to them. The term *impulse* is generally used to describe the preparatory reaction preceding some

definite response. We speak of the impulse to sneeze, strike, speak or drink. Any reaction may be preceded by an impulse. The impulse is essentially the awareness of the readiness or urge to act. When such an act as sneezing, coughing, or winking occurs promptly, following its natural stimulus, the impulse is scarcely observed. In the event of a delay, the presence of the impulse is clearly manifest. Under circumstances which render it impolite to sneeze, cough or wink, the impulse is specially vivid. The factor of impulsiveness, of urgency to action, is the essence of *interest*. To experience an interest in hats is to feel an impulse to see hats, or to react to them in some other way. A *desire* is also an urge to some action. To experience a desire to secure social approval is obviously to feel an urge. For every act or line of action, there are corresponding impulses or urges. Different terms are used to suit different types of impulsive experiences.

Impulse applies chiefly to specific definite acts; it implies, moreover, that the readiness to react is conscious, and may not, therefore, be applied so securely to animals concerning whose conscious life we know so little. The term *urge* does not necessarily imply ordinary consciousness and suggests a dynamic tendency of a more general character, such as the urge to secure food or sleep. It suggests a more abiding search for relief than *impulse*. *Cravings* or *wants* vary but slightly from urge. The terms *tendency to action* and *determining tendency* have been used to cover all varieties of impulses and urges. The terms have the advantage of not implying conscious processes and are therefore applicable to animals. They do not seem to us to be as adequately suggestive of the dynamic nature of the activities as impulse and urge. *Drive* has been used but its frequent association with external mechanical forces, such as drive a post or drive

a horse, renders it a bit less descriptive than urge. Mainly we shall use the terms impulse and urge but others may be used at times as essentially equivalent.

Are the Dominant Urges Native or Acquired?—The food seeking urge, used for the purpose of illustration, is certainly native. It is found universally and appears at birth; it could not be acquired, although all sorts of activities may be learned by means of which this craving is afforded relief. Other fairly strong urges appear, however, which at first sight seem clearly to be acquired. Consider a man who has become accustomed to smoking a cigar after dinner. When the meal is over, the urge to smoke becomes active. If the supply of cigars is unexpectedly exhausted, the annoyance of deprivation is usually evident. The urge may become very strong. The victim becoming increasingly restless may at length jam on his hat to walk several blocks to the store in order, as we may say, to "satisfy his habit." So with other types of acquired activities—the paper at breakfast, the afternoon nap, afternoon tea or tennis, the Saturday night trip to the movies—once they are habituated, the proper setting arouses the urge. Smoking or reading the newspaper is obviously acquired. Hence it would seem necessary to admit that many urges are learned. Some students, however—notably McDougall—are unwilling to make this blunt admission. True, they may agree that smoking is acquired and that it embraces a craving, but they insist on a deeper inquiry. How happened it that the man began to smoke? And when the answer is determined, they believe it will be found that the habit was initiated and sustained because it satisfied some other native craving. All habits, in a phrase, are born of instinctive cravings and live as their servants.

Before this view can be adequately appraised the main

human urges must be marshalled before us. But as this is being done, we shall encounter difficulties in deciding whether some are native and primary or secondary and acquired. Such cravings, as those for a smoke or for a game of bridge, we shall disregard—they are not primary and not nearly universal in the human species. We shall confine ourselves to those that seem to be universal; those that prevail everywhere. Universality is not, however, conclusive evidence of nativeness. In some instance it will be impossible to tell whether the urge is native and primary or not. Merely to know that certain traits are universal characteristics of humanity, however, is in itself interesting and practically important. In the list to be presented shortly, a number of urges generally believed to be at least universal, and by many, both universal and instinctive, will be presented with comments as to the likelihood of the trait possessing one or both characteristics.

Urges Aroused Primarily by Organic Conditions.

In the first group are a number of urges which are primarily aroused by organic conditions. Some are not aroused exclusively by inner conditions since external situations also exert more or less influence. Hunger, for example, primarily a response to organic conditions, is intensified by the sight and smell of food and reduced by unpleasant visions and odors. It is, however, difficult to activate real hunger except when a certain organic condition prevails in some degree. Usually such an inner state is the primary stimulus to which the urge is a response.

The main urges of this type may be described as follows:

1. The urge to secure food when hungry.
2. The urge to drink when thirsty.
3. The urge to secure air when breathing is difficult or air inadequate.
4. The urge to secure rest when fatigued or sick.
5. The urge to sleep when drowsy.
6. The urge to secure warmth when cold.
7. The urge to secure coolness when overheated.
8. The urge to secure action when well and rested.
9. The urge to mating when sexually aroused.
10. The urge to escape when frightened or injured.
11. The urge to get rid of painful, and disagreeable substances or conditions.

Relative Strengths of the Several Organic Urges.—To appraise the several organic urges in terms of their insistence when unsatisfied, in terms of the rôles which they play in habit formation or in terms of the good or evil, individual and social, resulting from such adjustments is a difficult task not as yet fully accomplished.

Rôle of the Sex Urges.—While admitting to the sex impulse great strength and importance, psychologists are generally of the opinion that Freud and his followers have given it an exaggerated potency. While the origin of life depends upon sex impulses, life itself is more than sex. Hunger, thirst, and impulses to secure air and warmth are, so far as living is concerned, equally insistent and probably equally influential in determining the course of life's endeavors. Marital relationship is broader than sex; there are problems of food and shelter, activity and rest, sympathy and parental labors, that require adjustment and may result in compatibility or lack of it. That thwarting of the sex impulse appears to be so conspicuous a source of difficulty in civilized

life is the result not solely of the strength of these drives but partly of the frequency with which they are aroused only to be inhibited. Delayed marriage together with the insinuations of shame and indecency and social taboos provide the soil in which perverted and distorted habits of body and mind may grow from entirely decent but persistent impulses. Better understanding and better management is required for the mating impulses which are in themselves but one of many native drives, and no more shameful, no more insistent and probably no more powerful than others.

Urges to Secure Rest and Action.—The urges to secure rest and activity are alternating; one succeeding the other. Both appear in all animal species; both are instinctive. Each is as insistent, in its proper time, as the other; both are of biological utility. Rest is protective; continuous activity without rest would be destructive. Activity, like rest, is satisfying. Action, quite apart from its results such as the securing of food, etc., is gratifying in its own right. We experience urges merely to be active; and such activity is its own sufficient reward. This is apparent in the play of animals, children and adults. Much of play is activity engaged in for its intrinsic enjoyment. Action of this sort is not without usefulness; it provides the opportunity for the development of ability to manage the body and mind. The individual who is inactive when not aroused by urges of hunger, thirst, sex, or others, will fail to develop as fully, will fail to acquire as many skills and as much information as the one which engages in activity even if for no other purpose other than the satisfaction which such action itself provides. In the impulse to be active is found the incentive and the occasion for learning, for acquiring facts and skills which may be utilized, not

merely later for adult needs as some have said, but there and then in adjustment to the conditions of life.

Activity, as here used, means not merely muscular activity but all forms—manipulative, vocal and mental. The undirected activities of animals and children include not only running, jumping, dancing, shouting, singing, manipulation but exploration and experimentation with the sense organs, the unraveling of novelties, the acquisition of information of all sorts. It is important to realize that the urge to learn is native and that learning is not wholly derived from ulterior motives but is satisfying for its own sake.

Urges to Escape and Reject.—These two urges, apparent in the prepotent motor reactions in infants, are natively aroused only on occasions by certain dangerous or disagreeable situations or substances. When aroused, the urges to escape or get rid of painful or disagreeable stimuli are exceedingly insistent and may produce most violent action. Such urges, in the course of time, may be aroused in the absence of direct stimulation by associated stimuli (by forms of associative learning to be explained in Chapter XI) and thus serve to activate precautionary activities such as the construction of houses, of protective clothes, carrying of weapons, destruction of dangerous beasts, insects, plants, bacteria, and the like. The urge to protect oneself from dangerous and noxious things and conditions in this manner becomes a considerable factor in the ordering of life.

The Importance of the Organic Urges.—That these organic urges are instinctive in man is almost unanimously agreed by competent students. There is a consensus of opinion, too, that such instincts are potent sources of human strivings. Men will go to great extremes to satisfy the urges of hunger, thirst, sex and

other organic needs. Under acute heat, suffocation or thirst activities for relief may attain the level of violence. The traveler lost in the snow or the unrelieved soldier may give way to the impulse to sleep even if death is the probable result. The sex impulse, fully activated, may overcome ideals of propriety and the fears of disgrace or punishment. According to the views of some, the main goal of human conduct to which our innate urges impel us is the attainment of a condition of organic comfort and the avoidance of organic distress. To some who hold this view, many or all of our daily endeavors, our intellectual, athletic, avocational and vocational pursuits, are conceived as strivings to achieve these ends. Our multiform activities, personal and social, are initiated and sustained in the service of our organic cravings.

Like the animals, among which these motives are more obviously paramount, men in general do not necessarily realize—indeed, probably rarely do understand—the forces which determine their conduct. As the influences which determine the distribution and control of the circulation of the blood are ascertained only by dint of extensive research so the factors which occasion and control human conduct in everyday life are disclosed only by diligent and skilled study. If the statement, then, that human activities are primarily, or even extensively enlisted in the services of organic welfare is a surprise to the average man and appears to be rather uncomplimentary to him, it need not be on that account incorrect.

Summary.—There can be no doubt on several points. First, that the impulses and striving aroused by organic needs are instinctive; second, that such urges and efforts are important springs of human activity in the everyday life of both adults and children, and third, that in-

numerable habits based upon these drives are formed—habits of which the initiating and sustaining forces may not be recognized by the one who possesses them.

The view that the organic urges are the sole or even the main springs of human action is a problem to which consideration should now be given.

Other Dominant Urges.

It may at once be said that many competent students of human nature believe that the organic urges by no means exhaust the list. They will not agree to the view that human strivings are limited, directly or indirectly, to efforts to appease organic cravings or secure organic satisfaction. Other urges, equally influential, are assumed to motivate human activity and learning. Some believe that many or all of these urges are instinctive, and that they are primary and irreducible to more fundamental cravings. The character of such suggested urges is indicated by the following list which is representative rather than exhaustive. Some of these urges will be scarcely acceptable as fundamental and primary; some will be subdivided into other possible urges. Each "urge" moreover is not to be thought of as single and indivisible but rather as a name applied to a group of particular impulses which are more or less similar.

1. The urge to collect and hoard.
2. The urge to excel and succeed—the "mastery impulse."
3. The urge to fight persistent interference.
4. The urge to fight for its own sake—pugnacious impulse.
5. The urge to be submissive.
6. The urge to secure sympathy.

7. The urge to hunt and destroy.
8. The urge to relieve suffering—"impulse of sympathy."
9. The urge to beget children—"parental impulse."
10. The urge to care for, protect, begotten children.
11. The urge to be in a group of same species—"gregarious impulse."
12. The urge to secure social approval.
13. The urge to avoid social disapproval.

In briefly considering these urges in turn, we shall consider several problems:

(1) Is the urge typical of, or practically universal in, mankind;

(2) Is it instinctive or acquired;

(3) Is it primarily and irreducible to other urges or is it secondary, merely the expression of other urges singly or in combination.

Collecting and Hoarding.—The child tends to approach objects which attract his attention, pick them up and cling to them. Often he carries them away to some place of storage. By some it is believed that this tendency to collect and hoard is instinctive and primary. It is believed that, in the presence of such objects, urges to seize and accumulate are aroused as instinctively as in the squirrel, and that to carry out such acts is gratifying like the appeasing of hunger. Quite apart from the value the objects collected may have as food or implements and the like, there is satisfaction in consummating the mere urge to collect once it is aroused.

According to this view, the urge to collect and hoard in a world of attractive objects becomes constantly aroused. The child collects at first bits of colored twine or paper, cigar bands, stamps, pictures, trinkets of all sorts; as an adult he may collect other things—rugs,

hunting implements or books—but the same sort of urge is present and the same sort of satisfaction in getting and keeping is secured. Man, then, according to this view may be described as instinctively an acquisitive animal; the urge merely to have and hold characterizes his life.

While the tendency to collect and hoard is usually admitted to be an important human attribute, there is some opposition to the idea that it is instinctive and primary. Some believe that it is a habit acquired by virtue of its effect in providing food, shelter, objects for manipulation or study, social approval and the like. While it must be admitted that the issue cannot now be decided, the acquisitive urge may be accepted as significant.

The Urge to Excel and Succeed—the Mastery Impulses.—The urge to excel and succeed may be subdivided into several, such as the urge to overcome opposition, to resist domination by other persons, to dominate or master things, to dominate other people, to excel a rival and to achieve success in undertakings. Each phase of the urge merits brief description.

The Urge to Overcome Opposition and Obstruction: —It is characteristic of children and adults to desire to go about their play or work without interference. To any kind of obstruction the native reaction is the arousal of an urge which results in vigorous activity, directed toward the removal of the obstacle. A child's toy which will not work, a door which will not open, a block of wood which will not split, a thicket which will not permit passage—all such impediments provoke impulses and acts to overcome them. So commands and restrictions, in so far as they interfere with activities under way, tend to arouse resistance.

The tendency to overcome obstructions and interference was shown in an interesting way in a laboratory experiment (by Morgan) in which a subject engaged in the task of typewriting was subjected to a number of distractions, such as the sounds of buzzers and bells, or sudden changes in illumination. He was at once aroused to overcome such interferences. His pulse ran up, his brow was wrinkled, teeth were clenched, the keys were pounded harder than usual, and in most instances the typing was kept up to the average, although more energy than usual was consumed.

Such behavior may be considered as due to the arousal in various situations of the urge to succeed, to complete a task, to consummate a purpose undertaken. Influences which interfere may activate more acutely the desire to succeed. When subject to the impulse, one may attack the interference. Physical obstacles, and distractions or the interference of persons and attempts at domination by others all tend to arouse the urge which aims at successfully overcoming them.

The Urge to Dominate People and Things:—The child not only resists interference and domination but he also likes his blocks to stay put, his horn to blow, his dog to come when called, his playmates to follow orders. This is another expression of the urge to succeed, to have his projects, whatever they may be, go through to a completion successfully. To succeed in any undertaking is intrinsically satisfying quite apart from the other results achieved such as facts learned, skills acquired, food, prizes, or social approval secured. This phase of the urge to succeed is often called the "mastery impulse." Adults show evidence of this urge in innumerable directions. To climb an imposing tree or chop one down, to breast a strong current, to "break" a spirited horse, to

ascend a steep hill "on high," to lift a huge weight, to down a worthy opponent in wrestling, to solve a knotty problem, to swing a big deal or boss a crew of men are particular ways in which the urge may find gratification.

The Urge to Excel a Rival:—A keenly satisfying form of success consists in the excelling of a rival. Man keenly loves competition. The gratification of outdoing a competitor is one of the mainsprings of interest in games and sports of all sorts—chess, bridge, tag, baseball, tennis. This urge operates from early childhood to the end of life. It takes uncounted forms; in practically any activity, the presence of another who may be taken (even if he is unaware of it) as a competitor adds zest to the work and elicits greater efforts from the worker. How effective the urge is when activated in this way will be disclosed in some detail later. (Chapter XVI.)

The Urge to Succeed, in General:—The craving for success, in all of its manifold forms, is one of the most interesting and important human urges. However humble or trivial the activity may be, if one is demonstrably a success—that is, if he can overcome the difficulties in the task, can master the situation and excel his accepted rivals—one of the keenest human gratifications is realized. These facts appeared interestingly in a study (by Meek) of the first efforts of children, three to five years of age, to learn to read words. Some succeeded quickly in mastering the first lesson but a few failed completely. Those who succeeded came back to the lesson happily on the second day. Those who failed were less eager, and after a few further failures were exceedingly reluctant, sometimes testifying to other more important engagements or hiding behind the piano. They hated this task which brought them failure even when they were praised for their efforts or otherwise

rewarded. Some who were coaxed back were skillfully shown how to attack the learning of the words. They succeeded. Next day, success again; and soon an entirely new attitude, a happy and eager interest in reading. Nothing makes functioning more satisfying than success; nothing stimulates further efforts to achieve like success. We do not like difficulties except as they provide opportunities for success. What we crave is successfully to overcome difficulties.

Are these several urges primary or merely a special combination or pattern of other impulses? They certainly seem to be intrinsic urges with a specific gratification. Are they native or acquired? We do not know. Some believe they are; others believe they are acquired by experiences much as the urge to smoke is acquired. Unlike the craving for smoking, the urges to succeed are practically universal. While it is possible that the impulses described separately as the urge to overcome obstructions and interferences, the urge to resist domination by people, the urge to dominate things, the urge to dominate people and the urge to excel a rival may be but several phases of a common urge to overcome difficulties or interferences successfully, it will usually be found convenient and helpful to think in terms of the particular forms.

Fighting to Overcome Interference.—The tendency to overcome obstructions to, or interference with, an activity under way is a close kin of the impulse to seek domination actively, and both are related to fighting. Think of a boy building a play-house. If all goes well, each nail driven and each board affixed satisfies his impulse of mastery, and the thought of the completed house is a stimulus to his self-assertion. Let some of the boards split or some of the nails bend, and the boy is aroused

to overcome these obstructions to progress. If things go from bad to worse, swelling rage may lead to a fighting attack in which the structure is utterly demolished. Or, with things going well enough, if another boy interferes by word or deed, disregarding commands to desist, he may be the object of attack. The stimulus in fighting is an interference with an activity under way. The pugnacious attack is simply the most violent form of the effort to overcome an obstruction in the path of one's action, and inasmuch as it is the last resort, it is a less frequent reaction. Fighting in such instances is not primary and its own sufficient reward; it is a means to an end. The removal of the obstacle or the successful issue of the combat, rather than the combat itself is gratifying.

The Alleged Urge to Fight for Its Own Sake.—By some it has been maintained that there is an urge to fight quite irrespective of the provocation or the outcome; a craving to engage in battle just for the satisfaction of combat. An investigator who followed the activities of boys' gangs found among these healthy and vigorous youths very frequent individual, "free for all" and intergang combats. The zest for battle appeared so keen that some have been led to believe that it was primary and irreducible to other urges. It was a zest for combat pure and simple. It is said, furthermore, than this impulse persists into adult life despite efforts to curb its expression. Most of us, it is said, liking battle but having an eye to propriety of conduct, and also to the danger of injury, get our thrills by reading about or observing others fight—prize fights have drawn gate receipts of a half-million dollars—or instead of fighting with tooth and fist, we learn to attack with cutting remarks, piercing looks or annihilating thoughts only. We

are, it is said, fundamentally pugnacious and to a degree feel the craving to fight.

It is not conceded by all authorities that this type of fighting urge—the mere craving for combat—is a universal human characteristic; much less that it is native or primary. It is maintained by some, for example, that fighting is always done to secure mastery or social approval or, under primitive conditions, to secure food, shelter, mates or some other reward. The "pugnacious mood" is also explained as funamentally depending on some interfering or disturbing factor, such as bodily discomfort or irritation—fatigue or indigestion—or upon thwarted cravings of some sort. Thus fighting is conceived as a secondary means to some end, to the attainment of satisfaction for some other urge, rather than as due to a specific craving for combat. Evidence necessary for a final decision is not available as yet; we shall therefore put fighting on the uncertain list.

The Urge to Hunt and Destroy.—The desire to hunt is sometimes included among the primary cravings. It is alleged that children at a certain age experience impulses to chase and capture small animals much as the kittens are observed to do. Later, as such reactions are killed off by training, it is alleged that the hunting impulses secure gratification in the teasing, and hounding of eccentric characters, unpopular leaders, or minority groups such as Quakers, Chinese, etc., in America, or in running to earth and destroying wild game, or even human beings as in the hastily conceived mobs or lynching parties. While such unreasoned brutality doubtless is prevalent among mankind, it may be accounted for in terms of other cravings and hence considered secondary. The early "hunting" of the child may be an expression of the food seeking or collecting impulses or mere curiosity;

the bullying of adults may be accounted for in terms of impulses to secure the mastery, to dominate and victoriously engage in combat. The hunting of game, widely enjoyed by men, may be similarly explained—food getting, collecting, mastery and successful combat are served at once. Hunting, then, is probably not specific and independent of other impulses. Although secondary and derived the zest for teasing, harassing, plundering, attacking and damaging is doubtless nearly universal in mankind.

The Urge to Submit.—Submission is the antithesis of the tendencies to overcome opposition, to secure mastery and to fight. Forced submission to an obstinate obstruction or to a superior opponent is frequent enough, but it is not a source of satisfaction. It is characterized by such behavior as weeping, anger, chagrin, envy, jealousy, shame or embarrassment. Frequently, however, there appears an impulse to submit when submission seems to be gratifying. The situation which provokes submission is one which obviously cannot be mastered. Thus the child may be submissive to the adult, the adult to a wiser or more influential person, or to society as a whole. Admiration, awe, reverence, veneration, "hero worship," are indicative of willing submission. Universal tendencies to be awed by, as well as to venerate and idolize unusual, unintelligible or powerful natural phenomena, such as winds, thunder, or the sun, perhaps are rooted in an urge to be submissive as well as in fear. We seem, then, to desire to have, as well as to be, a leader or boss. These two impulses are not inconsistent but reciprocal. In submission, one is unaggressive, deferential and admiring, behavior that is satisfying, when to it the attitude of the superior is appreciative and kindly even if dignified and condescending. In mastery, the positions are

reversed; the satisfaction is equally great but of a different kind.

The Craving for Sympathy.—The impulse to be submissive is closely related to the craving for sympathy. When submissive, we expect kindly and sympathetic mastery. Sympathy the human species universally craves. To secure consolation the child eagerly displays his injury; or as has sometimes been observed, inflicts a cut or bruise in order to reap abundant pity. For the same purpose, adults are disposed to show their bruises, relate their accidents, illnesses—especially the details of surgical operations—hardships and misfortunes. Some become chronically addicted to tales of woe as a means of securing bounteous sympathy. "Self pity" for misfortunes, real or imaginary, is in some measure practically a universal practice. To secure sympathy is clearly a strong and essentially universal human urge. It is doubtless one of the impulses involved in many instances of submissive behavior but probably does not fully account for all forms of submission. The urge to secure sympathy seems primary but it is not clear whether it is native or acquired.

The Urge to Relieve Suffering—the "Impulse of Sympathy."—While the urge to secure sympathy is strong and clear, the urge to express compassion by active efforts to relieve misfortune and suffering has not always been quite so apparent, at least not apparently primary and fundamental, in the human species. Yet sympathetic behavior of some sort is characteristic of most animals. Plaintive cries of distress and other evidences of suffering usually arouse in the human being an urge to relieve the sufferer. The prevalence of societies for the prevention of cruelty to animals, of child labor, for the relief of distress in foreign lands; public institutions

for the poor, homeless, blind, feebleminded and other types of good-will are evidences of a widespread urgent compassion. At the same time it is necessary to explain the extensive brutality exercised by man upon other men and animals with which history is replete. The explanation is that mankind is at once sympathetic and self-seeking. The urge to relieve suffering, we believe, is fundamental, but, living in competition with the urge to secure food, achieve success and mastery, collect and hoard, etc., it is often submerged. For social welfare, the sympathetic tendencies, obscure as they often seem, are of prime import. Because they are often overthrown by antagonistic urges, the home, school and church do and must join forces in encouraging and rewarding the sympathetic dispositions as a means of promoting the ideal social life, conceived by human intelligence but with difficulty achieved in human behavior.

The Urges to Beget and Care for Children—the Parental Urges.—The parental urge, first of all, must be distinguished from mere sex craving. The questions are: (1) whether there is in men, women, or both, a specific urge that is satisfied by having offspring, and (2) once children are begot, whether there is a specific satisfaction in caring for them.

It has not been demonstrated for man or any other species, that an urge, either instinctive or universal, for begetting children appears. It is true, of course, that most people desire children but this may be explained as a resultant of the desire for the approval and satisfaction and pride which follows successfully overcoming difficulties of living up to acquired ideals of duty and of successfully accepting the responsibilities of life. For women, the bringing up of children has the added zest of the most worthy, and for many, a relatively attractive

occupation. It seems unlikely, therefore, that there is a strong anticipatory urge, specific in character, to beget children. The interest in having offspring is probably secondary and acquired.

Once children are born, what specific fundamental urges are brought into play? Among competent students there is nearly unanimous agreement that the infant is a potent source of urges which are satisfied only by evidences of its comfort and well-being. The urge to care for and protect valiantly the begotten children is strikingly apparent in many animal as well as human parents. Mothers, human or animal, seem especially responsive for a time after birth perhaps as a result of their organic condition. It is unlikely, however, as suggested in the preceding chapter, that human parents have inherited motor activities of caring for the infant in forms approximating the elaborate, and apparently, instinctive behavior of many lower animals.

It is probable, then, that the human species does not inherit a specific urge to beget young, or complex activities of caring for the young, but that it does inherit urges to care for and protect the child, once begotten.

The Urge to Be in a Group—the Gregarious Impulse.—Gregarious animals, buffaloes, sheep and wolves, are those which live in herds or flocks. Others, such as cats, tigers and lions, are solitary beasts. Given the same opportunities to live together, they prefer solitude. The human species is essentially gregarious; the seclusive individual, rarely found, is regarded as abnormal. For these reasons, it has been usual to assume that gregariousness in man is a fundamental instinctive urge—a conclusion not universally accepted.

Strictly speaking, gregariousness is merely an impulse to be with other people. We feel more comfortable

under most circumstances when with companions; rarely does one choose to live in entire isolation. When quite alone we become uneasy and lonesome; solitary confinement is a torturous punishment which usually brings confession or breakdown. No one of repute questions the existence of the gregarious impulse, but several deny it a specifically instinctive character. They argue that it is acquired. Having lived with people from the first, we become "used to" them. When they are gone we feel at a loss much as we feel the loss of a pipe, a friendly chair or as we may feel an uncomfortable lonesomeness after leaving the familiar surroundings of home. More than that, from childhood others of our species have given us aids and comforts of innumerable sorts; we like to be with others because we have learned that they add to our security and comfort; they enable us, moreover, to satisfy our submissive, mastery, parental, mating and other impulses. Any one of these conditions, it is asserted, is sufficient explanation of the gregarious impulses. The gregarious urge at least is strong and essentially universal in man but whether primary and instinctive cannot now be said.

Urge to Secure Social Approval.—The impulse to secure social approval goes beyond the mere satisfaction of being in a group. The approving words, glances, smiles or attitudes of other people are among the keenest sources of satisfaction. In numberless direct or subtle ways we seek approval; the child, by displaying his repertoire of tricks; the youth, his strength, daring and skill; the adult, by means of personal appearance, clothes, relatives, social connections, wealth, achievement in business, politics, society, athletics, philanthropy, or by wit, generosity, aloofness, and in other ways too diverse to recount. Lacking superiority in skill or valor, social

virtues, personal appearance or intellectual accomplishment, one may resort to fine manners, fine talk, extravagance, boasting or arrogance.

Urge to Avoid Social Disapproval.—As approval is a keen satisfier, so social disapproval may make life intolerable. Our sensitivity to facial blemishes or bodily disfigurement, the misery occasioned by a social blunder or a public criticism, are as intense as they are irrational. We are disturbed even if a dog or a tramp acts disapprovingly. A Zurich psychiatrist, Adler, has developed a conviction that many nervous and mental disorders are the results of the continuous disapproval which physical defects or deficiencies may bring.

In many instances, the urges to secure social approval and avoid scorn are similar to the impulses to secure mastery and avoid domination. Both may, in fact, be operating at the same time, but there is a difference between them. One may check his self-assertive tendency to a point of submission or humility in order to be considered "nice," although here the desire for social approval is conceivably the mastering impulse in disguise. On the other hand—and here the distinction is clearer—a man may dominate his wife and family or his employees or debtors so severely as to bring the disapproval of all who observe, yet the hard master may enjoy the role. In the case of bullies on the school ground or elsewhere, the craving for mastery may run counter to the impulse to secure social approval.

Summary.—This completes a brief survey of the dominant human urges which have been suggested by students of dynamic psychology. Since the opinions as to whether each urge is native or acquired, whether primary and irreducible or secondary and derived and whether relatively strong or weak have not always been unanimous,

the student may be left in some confusion. Perhaps a brief summary of the discussion will be helpful.

This summary is intended to suggest the situation which a survey of the beliefs of a number of competent students would yield.

Designation of the Urge	*Is Urge Relatively Strong or Weak?*	*Is Urge Native or Acquired?*	*Is Urge Primary and Specific or Secondary and Derived?*
1. Urge to collect and hoard for its own sake	Medium	Uncertain	Uncertain
2. Urge to excel or succeed, in general	Very strong	Uncertain	Probably primary
A. Urge to overcome obstruction, etc., by things	Strong	Uncertain	Possibly A, B, C, D, E may be reduced to the primary urge to succeed
B. Urge to resist domination by people	Strong	Uncertain	
C. Urge to dominate things	Strong	Uncertain	
D. Urge to dominate or master people	Strong	Uncertain	
E. Urge to excel a competitor	Strong	Uncertain	
3. Urge to fight when persistently thwarted or interfered with	Strong	Probably native	Possibly reduced to 2
4. Urge to fight for its own sake	Existence is doubtful		
5. Urge to hunt and destroy, for its own sake	Existence is doubtful		
6. Urge to submit for its own sake.....	Probably not generally strong	Uncertain	Uncertain
7. Urge to secure sympathy	Strong	Uncertain	Primary

Designation of the Urge	*Is Urge Relatively Strong or Weak?*	*Is Urge Native or Acquired?*	*Is Urge Primary and Specific or Secondary and Derived?*
8. Urge to relieve suffering, etc.	Weak	Uncertain	Primary
9. Urge to beget children	Uncertain	Acquired	Probably derived
10. Urge to care for, protect, begotten children	Strong	Probably native	Primary
11. Urge to be in groups — gregariousness	Strong	Uncertain	Uncertain
12. Urge to secure social approval	Very strong	Uncertain	Primary
13. Urge to avoid scorn	Strong	Uncertain	Primary

While the origin of several of the urges listed, whether native or acquired, must be left in doubt pending the results of further observation and experiment, a number of human cravings which appear universally, or nearly universally, have been described at least. For the understanding of human conduct and for dealing with it in many practical ways, knowledge of the existence of these important impulses is of great significance. How the fundamental urges influence thinking, feeling and acting, how they modify and control habit formation will be disclosed in the next two chapters.

QUESTIONS AND EXERCISES

1. Take the tendency to collect and hoard objects. When does it first appear? When is it strongest? When, if ever, does it die out? Discuss the probability of its being either native or acquired.
2. There has been an educational doctrine based on the assumption that "nature is right, there can be no higher criterion." It is asserted therefore that children should be permitted to develop

without inhibition, that they should be permitted to do whatever is "natural" for them to do, on the assumption that nature is infallible, that no instinctive trends can be undesirable. In the light of available facts, how valid is this doctrine?

3. Is it reasonable to suppose that there may be urges and instincts, useful ten thousand years ago, that are not useful now?
4. What is the significance of this statement from William James: "Man has a far greater variety of impulses than any living animal; and any one of these impulses, taken in itself, is as blind as the lowest instinct can be; but, owing to man's memory, power of reflection, and power of inference, they come each one to be felt by him with a foresight of those results." Does James mean that man arrives eventually at a full understanding of the impulses which initiate his activity?
5. Which of the urges listed in the chapter do you experience most frequently during the day? Which least frequently?
6. Is the fighting urge as strong in women as in men? How would you go about discovering the facts by scientific investigation?
7. Is *play* an instinct? Is it universal? Could play be considered as the result of the operation of the instincts listed in the text rather than as a new instinct? Make a list of various forms of play among children or adults and analyze representative forms into the impulses operating. Is there anything left unaccounted for?
8. Doubtless nearly every boy who has heard of a Radio would like to have one. Is there a native urge to possess and use Radios? If not, how would you explain the boy's desires?
9. Why do people like to tease? Why do boys like to break windows, steal apples, torment peddlers, etc. Is there a sex difference in the urges behind these acts?
10. Are people generally thrifty? Do we collect and hoard too much or too little? If there is a strong urge to hoard, why do so few people accumulate sufficient wealth to support themselves in old age?
11. What are the main impulses involved in adornment? Is it a specific urge? Would a person living alone adorn himself much? Do men or women give more attention to adornments? Explain.
12. Which of the urges listed in the chapter are most prominent? Which ones persist through adult life? Which ones become

stronger in adult life? Which ones are taken into account by religious doctrines or public laws?

13. Name a dozen things which people do to secure social approval. Evaluate the strength of this impulse. Trace its development to maturity.
14. Name a dozen instances in which a slight suspicion of disapproval brings great mental discomfort.
15. How much would you pay to see a good football game, if you were the only spectator on the bleachers? Explain.
16. When does the child begin to be self-assertive? What are the reactions when he is hampered or suppressed? How do habits of stubbornness arise? How would you deal with a stubborn boy?
17. What are the main impulses satisfied by the boys' gang activities? At what ages are they most prominent? What specific activities are most prominent in them?
18. Which impulses are likely most readily to be gratified in the life of the teacher, the minister, the lawyer, the politician, the prize fighter, the argumentative person, the bashful man, the I.W.W., the Salvation Army, the laboratory investigator in science?
19. What impulses operate to make the following activities satisfying or annoying: the dance; a male group hike into the country; Christian Endeavor activities; hazing of freshmen; football for the players and for the spectators; smiles to acquaintances; praise of virtues; factory labor; domestic labor; sheep herding; confinement in prison; wearing war medals; wearing fine clothes; giving a big party; riding in a Ford; riding in a Rolls Royce; appearing in informal clothes at a formal dinner; facial blemishes; being a spendthrift; being a "jolly good fellow"?
20. Criticise the treatment of one or more urges mentioned in the text.
21. What impulses, if any, should be added to the list given?

GENERAL REFERENCES

The list at the end of the preceding chapter applies also to the present chapter.

A specially good treatment of the tendencies to resist domination, to secure mastery, etc., will be found in R. S. Woodworth's *Psy-*

chology, New York: Holt, 1922, Chap. 7. William McDougall, in his *Outline of Psychology,* defends the view that such urges as are described in the text are instinctive and primary. The opposing view is well presented in F. H. Allport's *Social Psychology,* Chap. 3. A recent discussion of urges, explained differently from the text, is given by L. L. Thurston, in *The Nature of Intelligence,* New York: Harcourt, Brace, 1924.

The studies mentioned in the texts are: J. B. Morgan, *The Overcoming of Distraction and Other Resistances,* New York: Columbia Univ. Archives of Psychology, 1916, and L. Meek, *A Study of Learning and Retention with Young Children,* New York: Teachers College, 1925, and Tomi Wada, *An Experimental Study of Hunger in Its Relation to Activity,* New York: Archives of Psychology, 1922.

CHAPTER IX

THE RÔLE OF THE DOMINANT URGES IN HABIT FORMATION

Original nature provides us with a number of tendencies to mental, emotional, and muscular activity. Events in the environment or in the body itself are constantly providing stimuli which arouse either immediate and conclusive responses, typically of the reflex type, or urges and states of readiness for further activity which are more characteristic of the complex instincts. The same may be said of acquired reaction patterns. They, like instincts, are aroused by stimuli from within the body or from some feature of the external environment and, if delayed, appear as states of readiness or as conscious urges to action.

Habits once well established operate in every respect like instincts. Many habits, however, are really the means by which native impulses are expressed, and habits, in this sense, are derived from instincts. There is a native impulse to manipulate and specific tendencies to make a number of particular hand and finger movements; but acquired forms of manipulation of toys and implements may satisfy the tendency to manipulation quite as well. In other cases, the acquired activities may be less directly, at least less obviously, akin to the native urges and yet activated by them. They may be, as it were, native tendencies in disguise. At least, a number of urges were discovered, which were so prominent and so

nearly universal in the human species as to make them worthy of consideration in connection with everyday life and habit formation. These were called the main human urges. Although their origin was not always apparent, their dynamic potency is considerable as we shall attempt to show in this chapter.

How Dominant Urges May Be Thwarted.

Why do we not always, if we feel an impulse, carry it through to its consummation directly? The answer is that the conditions of life often thwart the direct expression. The child very early finds his strong impulses subject to discipline; he may not eat, yell, throw when and what he pleases. As he grows up, he finds that the life of the school and playground offer other restrictions and each later year may add anew to the inhibitions of his conduct.

The sources of inhibitions of or restrictions upon the main urges may be grouped roughly as follows:

1. Other insistent but antagonistic urges.
2. Acquired habits, ideals, conventions, taboos.
3. Obstacles in the environment.

One fundamental trend may conflict with another or several others so that all cannot be gratified. Thus one's desire to accumulate may conflict with the counter desires to rest, secure immediate sensory satisfactions, or social approval by immediate display. The impulse to mastery may conflict with the impulse to avoid injury in physical encounter. The urge to experience the novel may conflict with fear of the unknown or with the satisfactions of familiar surroundings. The craving to dominate, when the objects are our own children, may conflict with the parental impulse to treat them tenderly.

The strong urges may be thwarted by acquired habits, ideals, religious beliefs, or social conventions. In time of war, instinctive fears of slaughter may conflict with ideals of patriotism. The impulses to pick up attractive objects run counter to habits and ideals of honesty. Beliefs established in childhood, religious and social training, or thoughts of consequences, may inhibit many sex urges. The strength of the impulses to collect and hoard, to dominate, to fight, to indulge sex are reflected by the Ten Commandments, and other religious as well as legal, economic, and social enactments. Were these urges more easily and generally controlled there would be little need of laws and courts, police and prisons, social taboos and prohibitions. The existence of these institutions and practices is perennial evidence of the conviction that all fundamental drives are not socially desirable, and that many of them must, therefore, be more or less completely diverted or held in check.

Finally, strong impulses may be thwarted by natural obstacles or realities. Barrenness of the soil, floods or drought, business depression, or the superiority of rivals may thwart many as may the death of parents, partners, or friends. One's desire to secure social approval may be thwarted by a disfigured face; to attain mastery, by an unimposing physique or inadequate intellect. Injuries, illness, and other misfortunes are the more annoying because they foretell other thwartings. If we have a steady job certain cravings, such as those for rest, freedom of action, display of authority, may need to be foregone; if we lack a steady job, others such as the desire to accumulate, to eat abundantly, to secure approval, are jeopardized. No matter how favorable the conditions of life, the thwarting of many primary impulses and wants will be constantly experienced.

What Happens When a Strong Impulse Is Thwarted?

What happens when an insistent tendency, being in readiness to act, is by some circumstance not permitted to act? A general answer to this question is as follows: Whenever the organism is ready to act in some way, for it to act is satisfying; and furthermore, whenever the organism is ready to act, for it not to act is annoying. A satisfying state of affairs is defined as one which the animal seeks and attempts to maintain; an annoying state of affairs is one which the animal attempts to avoid or change,—to which it reacts negatively. Both are conditions which demand activity and if the conditions are novel, the result of the activity is learning.

These general statements find concrete illustration in experiments upon a cat enclosed in a puzzle box. The animal is annoyed by such confinement and this provides the motive for efforts to escape. If the cat is at the same time hungry, food placed in front of the box adds another motive—a readiness to eat. If the way out of the box has been previously mastered or if the box yields to such activities as cats usually make in such a situation, the end results—escaping confinement and reaching the food —are at once accomplished. But if the box is unusual, the way out must be discovered by a series of trials characterized usually by many errors before final success is achieved. Here we have a typical form of learning; learning by "trial and error" or "trial and accidental success" as it is called. The cat bites, digs, claws, pushes, pulls, and makes other native and acquired responses to the several features, wires, slats, knobs, strings, openings, which the box provides; he tries and tries again, until finally the solution is hit upon, usually by sheer accident. Usually the whole performance must be undergone a

number of times before the "way out" reactions are thoroughly habituated.

In all essentials, man's behavior when thwarted in his efforts to satisfy some strong impulse is like that of the cat in the box. He tries in one way or another to secure the satisfying and avoid the annoying state of affairs. He differs from the cat by learning the "way out" of the latter or the "way to" the former more rapidly and with better retention. He differs, furthermore, in his capacity to make certain mental adjustments to the perplexing situation; adjustments which, although involving ideas to a degree quite beyond the capacity of the animal are achieved by the same "trial and accidental success" process that characterized the cat's escape from the box.

When the native impulse to collect and hoard, rest, dominate others, fight, secure social approval or sex satisfaction, or to satisfy other wants are thwarted by obstacles, or when they come into conflict with each other or with our acquired habits, beliefs or ideals, some way out of the dilemma is sought by the try-and-try-again process; that is, by means of our capacity to learn. The adjustments thus made are obviously acquired reactions; habits acquired in the service of the fundamental urges.

Individual Differences in Ability to Tolerate Thwartings.

Individuals moreover differ greatly in the degree to which they are annoyed by the thwarting of their wants as well as in the characteristic types of adjustment. Some people, we all know from observation, can maintain their poise in the severest storm of deprivation and misfortune, while others are disarrayed by the slightest swirl. Scattered between the two extremes are the other individuals, representing every intermediate degree but most thickly

clustered in the middle of the group. Those at the weaker end are often spoken of by students of nervous and mental disorders as "neurotic" or "psychopathic," which means, in a general way, easily upset, very sensitive to difficulties in adjustment, and consequently readily susceptible to nervous or mental disorders. The position which an individual occupies in the group, ranging from the most to the least "unstable," of which the "neurotics" compose the former end, is determined in the main by original nature, although disease, poisons, shocks, or hardships may pull one to a level far lower than his original position.

It is seldom easy to differentiate the neurotic or nervously unstable from the extreme case of general emotionality. In the purest form, the case of extreme emotionality represents merely an excessive organic reaction to stimuli. There may be internal disturbances of a violent type, momentary or persistent, with relatively little misinterpretation of the stimulating events. The individual may simply become readily embarrassed, chagrined, frightened, unnerved, angered, while quite aware of the irrational character of such behavior, just as many of us become more or less excited over a public performance while quite aware both of the irrational character and the futility of the perturbation. The emotionally unstable individual may make entirely rational and wholesome adjustments to his difficulties even though the difficulties are great, whereas the psychopathic individual is not only intolerant of his thwartings but is unfortunate if not irrational in his adjustments. Emotional susceptibility, however, predisposes to unfortunate adjustments and unfortunate adjustments may aggravate emotional susceptibility.

What is meant specifically by the extreme neuropathic

or psychopathic dispositions can best be explained by detailed consideration of particular adjustment tendencies of which there are several forms.

The Mechanism of Introversion.

One of the most familiar and certainly one of the most convenient ways of securing indirect exercise of a thwarted desire or impulse lies in the substitution of imaginary for actual conditions. Among children, the common day dreams of candies, cakes, toys, and fairies are samples. The imaginary companions of the lonesome child, which occasionally become phantasies, and the "white lies" due to confusion, in recollection, between the real and the fancied, are the products of similar mental mechanisms more extreme in their operation. Among adults, the same tendencies are found, working along grown-up lines and normally with little confusion with actuality. Excessive day dreaming of the realization of desires is technically called *introversion* (meaning to turn inward) and the extreme *introvert,* at least when subject to confusion of fact and fancy, would be commonly classified as abnormal or insane.

The "Conquering Hero" Type.—Among introversions there are several tendencies which are alike with respect to the mental processes involved and with respect to the fact that they are, in some way, clearly satisfying. Perhaps most common is the form in which various strong impulses—the urge to secure social approval, mastery, etc.—are gratified by playing one's self, in imagination, as a "conquering hero." One may picture himself as a hero in battle, on the gridiron, in the prize-ring; as a great bandit, singer, or preacher; as the strongest, most admired—indeed, as the superlative in any line, even in benevolence or modesty. By some imaginary ability or

achievement one becomes an extraordinary person—a conquering hero—to whom imaginary approval and applause are due.

These are perfectly normal and universal day dreams which bring much satisfaction and little harm to most people. But in the extreme form they may be disastrous; indeed, they resemble the delusions of grandeur found in Paranoia, a form of insanity. The victim of delusions of grandeur has become an extreme introvert or has somehow lost his grip on reality so that he believes and tells you at length that he is the strongest, wealthiest, or in some other way the greatest man on earth. Of course, these systematic delusions indicate neurotic organization to begin with and may be long in developing into the extreme form; but fundamentally they are achieved by the same kind of mental functioning which results in the harmless self-aggrandizement of youth and the ordinary, flattering day dreams of adults.

The "Suffering Hero" Type.—Another tendency of imagination or introversion is typified by the ideal experiences of a suffering hero. While less frequent than the conquering-hero variety, this form of imaginary experience is equally intelligible and equally satisfying, to some people, at least. The fancies may run something like this: a boy, ruminating over his hard luck and ill treatment (as he sees it) at home or school, pictures himself as forced to run away from home. He imagines himself joining a group of bandits and going to the bad completely, or perhaps overwhelmed by a snowstorm or wild beasts, by which he is injured or even killed. Meanwhile, parents, teachers, some little girl, in fact the whole village has become alarmed and repentant, and after vigilant search he is brought back a hero, even if a wounded one. But perhaps he dies, and if so, it is any-

thing but annoying for him to hear the imaginary obituary, in which his virtues, appreciated heretofore by none but himself, move the congregation to heartrending grief and remorse.

Introversions of this type are highly gratifying partly because the subject is, after all, a hero who achieves acclaim and partly because approval coupled with sympathy and pity are all the more sweet. Self-pity, which is typical of many neurotics is well fed by introversion of the suffering-hero type.

The suffering-hero mechanism is often behind such childish behavior as pouting, sullenness, pretended injuries or illness, refusals to eat or to play. If the new doll or dress is not quite up to expectation, the child is angered and will not have it at all. A real or imagined slight at the party sends the boy home in indignation or grief. As a rule, real actions of the wounded-hero type are cured more readily than are thoughts. The boy who refuses to eat finds, after all, that no one else is much disturbed, whereas he gets dreadfully hungry; he who leaves the party learns that he misses a great deal of fun without being himself missed. But the imagined acts of this sort come out more happily. Imaginary starvation is more tolerable, and the imagined remorse and pity caused by it can be secured, whereas real sympathy from others is not always forthcoming.

Some forms of delusions of persecution in the insane have many features in common with the suffering-hero introversion although others are developed in different ways. Overt acts of martyrdom, ranging from refusals to eat or play to the infliction of injuries upon one's self, from the simulation of illness to actual suicide, may be the outcome of prolonged or impulsive introversion of the suffering-hero type.

Identification.—A somewhat easier and often more vivid substitution for genuine action of the sort instinctively desired may be secured by identifying one's self with the conquering or wounded hero or with other characters in fiction or on the screen or stage. When the boy reads Treasure Island or Robinson Crusoe he actually becomes the adventurer. With Nick Carter he holds up trains, kills Indians, overcomes ferocious enemies, drops over Niagara, and has other experiences at which his original nature thrills but to which it scarcely dares lead overtly. Similarly, we may identify ourselves with the righteous and heroic sufferer, and weep real tears at our imagined hard lot. The heroes and heroines as well as their experiences may change constantly or, doubtless less frequently, we may persistently identify ourselves with a real or represented character, following his achievements in great detail. The rôle of the finest character or the greatest rogue, the most applauded or the most chastised, may be the object of identification and thus lived in imagination with great satisfaction.

Within limits, and properly controlled, the play of imagination or identification is productive of little harm, while providing much satisfaction. The student, struggling without time or means for immediate gratification of his impulses, is comforted by the vision of wealth, power, and approval that he may some day attain. The introversions should be of the right sort, however. Imaginary achievements as a rule, if not invariably, are more wholesome than imaginary grievances. One may get along very well on imaginary power but not very well on imaginary food. Fancy must not disregard fact nor become a substitute for action. It is in this possibility of imagining fine adjustment while achieving none that danger lies.

Types of Rationalization.

Mental adjustments may also take the form of rationalization although irrationalization would be the more descriptive if less commonly used term. Rationalization is a form of thinking or reasoning, that is, of sifting data, in which our personal desires are selective factors which guarantee an agreeable conclusion. Ideally, reasoning is the process of impartial manipulation of the evidence to achieve the logical conclusion, however disastrous the result may be to our own wishes. Rationalization means more or less complete blindness to all evidence except what furthers our side of the case. In every-day life this irrational process is often so subtle as to leave us oblivious of its existence.

The Rôle of the Main Impulses in Rationalization.—A middle-aged man with a wife and family buys a handsome automobile. His older and more sagacious uncle, paying a visit, questions his motives in this purchase: "It seems to me," he says, "that you need furniture, a new fence, a fund for sending your children through college, a nest-egg for emergencies, more than you need this machine." But the buyer has a ready defense. "Well, my wife hasn't been any too well and I thought that a little week-end trip now and then would do her a lot of good. And a busines man must have some recreation, you know! Then the children. They caught so many colds last winter because they got wet going to school"—and so on with other "reasons." Now, what were the real motives? Perhaps the fact that other neighbors had cars which were veritable badges of greater business success. Perhaps driving a big machine appealed to the urge of self-assertion. Perhaps the approval of onlook-

ers was the object sought. Observe the motives to which advertisements of high-class cars appeal!

The real motives often lie deeper than those we give, and what is equally significant, we often do not ourselves appreciate just what they are. Rationalization is a subtle process; it provides acceptable reasons while concealing the fundamental motive. The most effective temptations are those which come in disguise. If we are inclined to take the afternoon off for golf, while really aware that we should work, we at once obscure the real issue by rationalization, by camouflaging the unworthy impulses. The student says to himself, "I have been working hard; I deserve a rest; I must be careful of my health; a little recreation will double my capacity tomorrow." And the next morning, to justify faith in himself, the student rationalizes the sore muscles and aching back as symptoms of renewed strength and vigor; or the excessive fatigue as evidence that exercise was sadly needed. These excuses and explanations are as persuasive as they are irrational.

Projection.—Failure to secure mastery, social approval, or to satisfy other strong urges may be partly averted by a form of rationalization called projection. There is a universal impulsion to project the trouble to some cause other than our own deficiency. If, while groping our way across the room in the darkness, we thump our shin on a footstool (due to our own forgetfulness), our immediate impulse and not infrequent act is to reproach the footstool rather than ourselves. Missing a stroke in tennis, we look inquiringly at the racket, ball, or net. The clumsy carpenter accuses his tools. If we fail in an examination, the questions were unfair. If one is a slave to alcohol, the taste was inherited from his father. If a man sins, it was because he was irresistibly tempted. If he amounts

to nothing, it was because he did not have a chance. There was once a man who exclaimed when his carelessness resulted in the burning of his home: "It was the Lord's will."

By projection we escape the annoyingness consequent upon the admission of our failures and deficiencies. The chronic alcoholic, notorious for projecting the cause of his downfall, affords an example of this mechanism. It would be most painful to admit that one is not only a worthless drunkard but also the cause of untold suffering to one's wife and family. The chronic drinker, finding it impossible to give up the liquor, casts about, like the cat in the box, for some means of escaping these unendurable thoughts. Perhaps, some time as he arrives at home intoxicated, the wife indignantly drives him out of the house. Thinking the matter over at the corner saloon, it occurs to him that he would not be drinking now were it not for his wife. This affords a crumb of comfort. He broods over this and other real or imagined events until he has convinced himself that his wife has been, even from the beginning, the cause of his downfall. That these delusions free him from responsibility not only for his own ruin but for the sufferings of his family is motive enough for clinging to them tenaciously.

The "Sour Grapes" Mechanism.—As the fable goes, a fox, after many vain efforts to secure an attractive bunch of grapes, preserves his pride and assuages his appetite by declaring that the grapes were sour; quite unfit for consumption by one of his caliber. This portrays a common method of human adjustment, a tendency to minimize or deny the desirability of the ends sought. If we lose our job through inefficiency we convince ourselves that the loss was a blessing in disguise. If we find masterfulness difficult to attain, we may say that more than

anything else we despise pretentiousness. Being poor, we assert that money is the root of all evil. Unfit for or unsuccessful in marriage, we declare wedded life a failure.

A rather general belief in compensation among human abilities has arisen from this tendency—a conviction that people extraordinarily competent along one line must be deficient in another. If the other fellow learns rapidly he will retain poorly. The pretty girl has little sense. The highly intelligent are nervous, unstable or physically inferior. All of these generalizations are, in fact, incorrect and thus disclose the more clearly this unique human tendency.

The Converse of the "Sour Grapes" Mechanism.—A fox finding none but sour grapes declares that they are just the kind for which he had been searching. And so, Pollyanna finds that no matter what the calamity, one ought really to be pleased because it might have been worse. Living in a hovel, we declare it easier to keep tidy and much more comfortable than a big lonesome house. Lacking mastery, we find supreme virtues in meekness.

The "sour grapes" mechanism and the Pollyanna forms of adjustment betray a weakness. To declare that really desirable achievements or rewards are futile or depraving seldom uproots our wants, at least not those grounded in strong native trends. Furthermore, the fruits whose desirability was once denied later may fall within our grasp, whereupon we must either scorn them again or else lay ourselves open to the attack of inconsistency.

Both forms of adjustment are negative—let things come as they will and make the best of them—rather than progressive. It is the adjustment of the inactive; the same old sour grapes are good enough. If they are really sour, it would be better to search elsewhere for sweeter

ones. It is the opposite extreme of adjustment tendency from the behavior of one who, finding a high wall in the path of his progress, attempts to go under it, or over it, or around it, and, all of these failing, goes around the world to come up on the other side.

Prejudice and Logic-Tight Compartments.—Systems of ideas developed by rationalizations of any type, beliefs, superstitions, prejudices, grudges, or habits developed in childhood or later often become so firmly established that they can scarcely be dislodged even in the face of substantial evidence that they are irrational, useless, or even harmful. Such acquired systems of response, impenetrable to logical attack, have been called logic-tight compartments.

Among the milder forms of logic-tight compartments are our convictions of the superiority of our town or county, our college, or ourselves. Several investigations have shown a very usual tendency for people, even those of high intelligence and broad training, to overestimate their abilities and virtues and in particular for those who are generally regarded, for example, as decidedly snobbish or vulgar to be blind to the facts. It is easy to see that these erroneous beliefs are motivated by our instinctive desires. In various ways we may close our minds to the arguments which run counter to our desires and cherish those which favor them. In the course of time, these prejudices become fixed.

We may have closed minds in various degrees, ranging from the slight distortion of facts required to provide a comforting explanation of failure in an examination, or that of a male clerical worker who may not himself see any relation between his fear of competition and his conviction that "woman's place is in the home" to the extreme type of the man who, while scrubbing the floor of

the asylum, stops to tell you that he is a millionaire. While we would call the last a case of insanity and the first just a "natural feeling," both are similar mechanically, differing mainly in the degree to which misinterpretation is carried. The delusion of being a millionaire represents logic-tightness to a degree of absolute immunity to which the term dissociation is often applied.

Defense and Escape Mechanisms.

Psychologists and psychiatrists frequently classify as dissociations not only systems of ideas or prejudices but also bodily functions. A patient may be at times uncontrollably nervous, hysterical or morbid; he may be weak, paralyzed in one part or another, blind or deaf; he may have pains, seizures, fainting or vomiting spells, dizziness or heart disorders. The term dissociation is here merely descriptive; it indicates that some function has been broken off from control of the "main" personality. What interests us in these cases is that, while not the product of rationalization as heretofore described, they are none the less acquired as the result of some motive and may persist as long as the incentive continues. The motive is rarely understood by the patient. The symptoms are the result of what is called a "defense mechanism" producing protection from some distasteful or fearful task or condition or "escape mechanism" affording an escape from some annoying or horrifying task or condition in which the patient finds himself.

Samples of Defense Mechanisms.—A badly pampered young man of a somewhat unstable type began his career as an accountant. Before many weeks he was brought home complaining of severe pains in the eyes and in the right arm, which seemed partly paralyzed. Feeling better after a few days' rest, he returned to his work, only to

find the attacks recurring. The significant thing about these symptoms is that they made his work in the office impossible. Actually, the young man found the tedious task at the desk, day in and day out, extremely boring, and the work deprived him of the freedom and comforts which home life had previously given. At the same time, he was naturally averse to quitting outright—that would offend his self-respect and bring the scorn of his friends as well. Perhaps, one afternoon the fatigue of eye and hand did become severe, providing an excuse for release from labor for the day. The next day, the same symptoms occurred in more severe form and, half frightened and yet half gratified, he was taken home. Not only did he thus escape the unpleasant work but the criticism of himself and of others as well. In fact, he reaps more sympathy, freedom, and general care than ever.

Psychoneurotic Disorders Considered as Defense Mechanisms.—Many of the "psychoneurotic symptoms" of soldiers during the war (often called "shell-shock" improperly since they frequently appeared in soldiers who never reached the front) were of the same general type, similarly occasioned. It should be observed first that the symptoms, such as paralyses of the arm, fainting spells, temporary blindness, vomiting, etc., provide "escape" from or a "defense" against arduous or dangerous military activities. It should be stressed again that such symptoms do not imply pure malingering; they are intentional, although motivated by human tendencies to seek safety and ease and avoid danger and hardship. They are as perplexing and unintelligible to the patient as to others, but they result, nevertheless, in "escape" and often bring unusual care, attention and sympathy. The remarkable, and yet wholly intelligible, thing was the rapid disappearance of the psychoneurotic disorders after the Armis-

tice was signed. The motivation, the incessant stimulus which kept them alive, was suddenly removed; and as subtly as the symptoms appeared in the face of war, they began to disappear with the certainty of peace. The symptoms were no longer a defense against the labors and danger of war but a prevention of exchanging the confinement of the hospital for the freedom of private life. Many of the symptoms disappeared abruptly, others slowly, still others like other unfortunate habits were more persistent. Thus subtly is conduct guided and controlled by our fundamental urges.

Substitute Activities or Compensations.

The various forms of introversion and most of the forms of rationalization were mental adjustments to the situations which interfered with or inhibited the direct expression of native impulses. In one way or another some mental activity was substituted for overt action. More active adjustments may also be made even when the substituted activity is in most respects quite unlike the original form. For example, a man who has been enraged but who does not dare to give rein to his impulses to attack because of his fear of injury, or jail, or perhaps because he doesn't believe in fighting, may substitute an attack with words or looks, or he may control himself for a long time but may later vent his rage upon his wife or children. In the same way, a man of frail stature, failing to secure a feeling of mastery by his physique, substitutes (quite unwittingly, perhaps) a dignified gait and manner, or develops a loud, "masterful" voice, or a hard, even gaze. A woman, lacking beauty or wit, may, to secure approval, adopt gorgeous apparel or affect the élite in vocal expression. The unprepared student in writing his examination may compensate in

volume for what he lacks in facts. A man low in the scale of authority at his place of work, submissive to others throughout the day, may find a satisfactory compensation in ruling his wife and children with a stern and unrelenting will.

Undesirable Compensations.—Substituted activities may be good or they may be bad; some are very bad indeed. That addiction to alcohol, heroin, morphine, or other drugs may be considered as compensations for thwarted desires or ways out of annoying situations, is a growing belief. Dr. Richard Cabot, Professor of Medicine in Harvard University, writes: "We hear a great deal of the physical craving for liquor. I do not believe there is any such thing except in the people who are in the middle of a drunk. A person who has slept it off . . . may well enough go back to it and of course he often does. But he does not go back from merely 'physical' craving, but generally because he is bored or because he is blue or because he is restless." That Dr. Cabot had in mind thwarted impulses or annoying conflicts from which alcohol has provided an escape, is indicated in this further statement: "The alcoholic is helped, so far as he is helped at all, by getting at the reason why he started drinking and has continued to drink. Then if possible we try to find a stronger motive, a motive stronger than the thing that has driven him to drink and thus drive him out of drink."

More Desirable Compensations.—A substitute activity, then, may get one into difficulties worse than the trouble which the activity aimed to relieve. But there are good as well as bad forms of compensation. If the maternal urges are thwarted, better than idle day dreaming, or novel reading, or a pessimistic view of life, or "sour grapes" or a cheery indifference of the Pollyanna

type, better than some silly or harmful compensatory activity, would be the substitution of some social, religious, or educational work. For the fighting, hunting, dominating impulses of youth, vigorous athletic games may be substituted. When angered, instead of holding a grudge, or inflicting damage on the offender in fancy, or working off the impulses by verbal attack upon inoffensive persons, we might attack the woodpile. A man who had lost his wife and children, in a terrible calamity, instead of avoiding the anguish by way of delusions, or liquor, or giving up to a wounded-hero type of self-pity, plunged more deeply than ever into his work and so instead of becoming a "ne'er-do-well," a drunkard, or a pessimist, became a very eminent soldier. Of all the methods of adjustment to the thwarting of our fundamental impulsions, the substitution of some wholesome but vigorous activity, while not always the easiest to arrange, is by far the best. When the lives of men are deeply searched, great achievements are found in lines of activity which began as substitutes for some other interest that was thwarted.

Repression and the Unconscious.

In the writings of Freud and many other exponents of the "psycho-analytic" schools, the term "repression" into the "unconscious" or "subconscious" appears extensively. According to many of these writers, repression is conceived as a subtle mechanism by which many thwarting or painful ideas or "conflicts" or impulses under taboo may be temporarily avoided by banishment from consciousness. Sex impulses (which the Freudians find to be most numerous) may arise in forms tabooed by our ideals or training. We cannot allow these impulses to be expressed directly or even by day-dreaming their realiza-

tion. Attempts to rob them of their attractiveness by some form of rationalization, by the sour-grapes mechanism, for example, may fail. What we may do, according to the Freudians, is to relegate them actively into the subconscious; that is, to repress them. Once submerged in this lower region, they become unconscious—we become unaware of their existence—but though buried they are really buried alive. Still active, they may express themselves in some indirect way, often in most mischievous ways. They may come out during dreams—a time when our inhibitions are at a low ebb—in some symbolic or even direct form. During waking hours, the repressed ideas or impulses are more closely guarded by the "censor," that is, by our ordinary taboos and inhibitions. Their appearance then must be very deceptive; consequently they take the form of headache, nervousness, fears, forgetfulness, pains, paralysis, or stuttering. Even slips of speech or writing, difficulties in recalling a name, perseveration of a tune, or giggling are ways in which repressed impulses are satisfied. Many nervous disorders, it is said, are occasioned by these unconscious ideas and impulses. Such symptoms are unconscious motives in disguise.

When explained in detail, the Freudian concepts are fascinating and often convincing. Yet they have not met with approval in most scientific, especially psychological, circles. The trouble is that while they fit in well with popular notions, the concepts are really scientifically unsound.

The Unconscious and Subconscious Ideas.—There may be, in the body, activities which are unconscious; that is, activities which arouse no sensations. Our digestive processes may be going on, active yet unconscious. The seat of consciousness is, of course, the brain and not

the stomach. Unless the motor and glandular activities, through sensory nerves, arouse to activity certain neural mechanisms in the brain the digestive processes arouse no sensations, that is, they do not become conscious. The trouble begins when it is assumed that the sensations from the stomach, even if not experienced as conscious, nevertheless actually exist somewhere, namely, in the unconscious. The fact is that unless they are conscious they do not exist at all—in the subconscious mind, in the brain, or in any other place, any more than words exist as things in the vocal organs when these organs are inactive. "Where," it is asked, "is a memory or idea when it is not conscious? Where is the idea of my birthplace when I am not thinking of it? Is it not still a genuine, live idea although not in the region which we call consciousness? Given a chance, will it not leap out of the unconscious into full consciousness? Is this not the process of recollection?" Now this doctrine is as perverse as it is simple. Memories and ideas are not things, which must always exist somewhere. They are merely conscious responses to appropriate stimulation just as movements are muscular responses to stimuli. We do not say that a movement is something actually existing but concealed in a muscle, from which it emerges when activated and to which it returns during inactivity. What we say is that a mechanism, the muscle, when properly stimulated by means of a nerve impulse, is thrown into action, with a movement as the result. During a period of inactivity, the muscle does not contain an actual movement; all that exists is the muscle with its nerve connections modified as they have been by past exercise. Likewise, the physical basis of conscious recall is assumed to be a group of cortical mechanisms similarly conditioned by past exercise and thrown into action by stimuli. In sum, an

idea, memory, or impulse is like a motor response, in the sense that it is a reaction. It is retained in the same way that an acquired motor act is retained. Neither a movement nor an idea exists as such except when it is activated; at other times, neither exists in the unconscious—it is simply inactive.

Unconscious Impulses.—Impulses to eat, sleep or dominate are, like movements or ideas, due to reactions of certain mechanisms; and except when the mechanisms are active, the impulses do not exist. The impulse to eat, for example, is produced on occasions by organic conditions such as that of insufficient fuel in the system, or by outer stimuli such as the sight or smell of food, or —best—by both together. Readiness to eat does recur, not by popping out of the unconscious but as a reaction to organic or external stimuli. Similarly, the sex impulses are aroused by certain bodily conditions or by an external stimulus or by both together. Impulses, like memories, are reactions; they exist only when active; at other times there is nothing except the mechanism on which they depend. When not in a state of activity, impulses do not actually exist as entities in the unconscious or in the mechanisms which give rise to them any more than snaps and pops exist, as such, in an inactive whip.

These are really not trivial or academic "distinctions without a difference." The Freudians, having gone astray because of the erroneous assumption that every one carries around with him a host of active entities in his unconscious, next assume that these hidden but uncannily active—in fact, intelligent—beings disguise themselves and break out, causing slips of the tongue, dreams, fears, nervous disorders of the various sorts which they find in their patients. There is a tremendous

difference between the Freudian statement that the accountant's eye and arm disturbances (mentioned above) are due to the work of active entities from the unconscious and the explanation that these troubles were actually learned in much the same way that the cat learns, after many errors, to pull a string which opens the box in which it is confined.

Inactive and Dimly Conscious vs. Unconscious Ideas.—This Freudian mechanism of avoiding unpleasant thoughts or impulses by actively pushing them into the region of the unconscious where they still exist and stir up trouble—psychoneurotic symptoms, for example—we cannot accept as true or useful. That we do attempt to avoid unpleasant thoughts and impulses is not denied but strongly affirmed. Mainly our efforts to forget are efforts to substitute another activity. A frequent device, when one thinks of some social blunder, or some undesirable impulse, is to begin to sing, write, read or do something else. We get the unpleasant idea out by getting another one in. The unpleasant thought or impulse may still persist in the background of consciousness and still influence our behavior as the dim awareness of an important event influences our activities and moods, or they may disappear entirely from consciousness. In the latter case, the ideas and impulses are merely inactive; they are not relegated to a different region where they still remain active in mysterious, not to say, fantastic ways.

Summary with Certain Implications.—The various typical ways by which man escapes the annoying situation occasioned by the thwarting of native tendencies, by day-dreaming the activity, by "sour-graping" it, or by pretending that the annoyingness is really satisfying, by rationalizing an excuse for the indulgence, or by substituting some other activity, good or bad—all of these are

acquired adjustments. They are learned reactions, just as speaking English, fearing the plague, or cracking nuts are learned reactions or habits. To say that they are learned is by no means to say that they are understood. Just why or how, and often when, he learned to enjoy stories of travel, to whistle or to count, generally is not understood by the learner, nor does he usually know with any definiteness how he now whistles or counts. The purpose of this chapter has been to present in general terms a number of acquired adjustments to annoying situations provoked by the hampering or thwarting of fundamental tendencies to action; and to illustrate the fact that many habits are formed in the service of the dominant impulses. The detailed processes involved in learning or habit formation remain for later chapters and in none of them will it be found necessary to invoke the use of uncanny subconscious or unconscious entities or mystic powers of any sort.

Remedial Measures and "Cures."

The Prevalence of Psychoneurotic Ailments.—That our adjustments to difficulties are both good and bad, that they vary from mild and quite harmless habits to most severe "psychoneurotic symptoms" has been stated. Not infrequently the unfortunate defense mechanisms or compensations, excessive introversion or other adjustments are such as to interfere with normal contented living. The victim believes he is ill, as indeed he is, but the illness is the realm of general behavior and is not a disease in the ordinary medical sense. It is said to be a "functional" or "nervous" rather than an "organic" disturbance. It is often severe enough to cause the victim to search for expert advice or aid. "Half of any general (medical) practitioner's ordinary work," writes Dr.

Richard Cabot, "is concerned with some type of psychoneurosis; not half that the neurologists do, but half that all of the doctors in the country are doing today, is to treat psychoneurotics. That is important in many ways. It seems to me most important, because very few of the doctors have ever been trained to treat a psychoneurotic; very few have an interest in it. The attitude of many a doctor is expressed by his desire to run out of the side door when one of these patients appears at the front. He hates them, but cannot afford to show it." By this statement of an eminent physician, two facts are implied: Disturbances in behavior generally of a character serious enough to occasion a visit to a doctor are as numerous as organic disease and treatment by ordinary physical measures are apparently of little value.

How Such Ailments Are "Cured."—The histories both of medicine and charlatanism are filled with stories of "cures," supposedly of disease, but really of psychoneurotic symptoms or ailments. The psychoneurotic soldiers, above mentioned, were "cured" when the conditions surrounding their symptoms were altered, when the motives were removed or reversed. Usually the "cure" was effected only after some "treatment." What the treatment should be would vary with the individual; for some a strong electric shock, for others exposure to complicated apparatus, for others drugs, for others suggestion or a heart-to-heart talk. The "treatment" was really but a stimulus to arouse a change about to occur, a mere signal to move in a new direction. All down the ages this has been true; marvelous "cures," one after another, are given the credit for the change fundamentally due to a shift in motivation.

The Varieties of "Cures."—The main requirement in such a cure is that it shall be notable or novel or nasty.

Cures by legions have been effected by notable personages, novel appliances and nasty nostrums. Valentine Greatrakes in the seventeenth century by the laying on of hands, Pfarrer Gassner in the eighteenth by word of mouth, Phineas Quimby of the nineteenth by his "magnetic eyes" and strokings, Emile Coué of our day by suggestion and incantation have "cured" hundreds or thousands of the typical psychoneurotic symptoms—pains, lameness, contractions, dumbness and so on. Less eminent curers were effective, too, on a smaller scale, such as the traveling "doctor," who has long been with us. Uncle Henry describes him thus for Colliers: "The doctor I remember best was Professor Hieronymus—vital healin', he called it. No knife, no medicine nor nothing. Why, magnetism poured out of him like sap out of a sugar maple. For $2 he'd take plain tissue paper between his palms and vitalize it, an' all you had to do to keep well was just pin it on your night shirt at the back over the great nerve center of the human body." Before his day primitive tribes had their "medicine man."

Similarly effective has been the use of mechanical appliances; in which novelty, something new or mysterious, is of prime value. Thus when the first inklings of electric forces began to flow, magic "tractors" (sometimes made of wood), electric belts, batteries, and especially highly complicated and spectacular apparatus began to accomplish cures. The blue glass craze, during which hundreds were supposed to have been cured of all sorts of ailments, was reputed to have originated in the humorous remark of a wag to a sufferer that blue glass should cure illness because the rays were "actinic." Quite aside from their legitimate functions, X-rays, radium, plasters, chest-protectors—especially red ones—etc., etc., have been potent in relieving psychoneurotic symptoms. Drugs

have been equally potent, especially nasty drugs—few have much confidence in a drug as bland as water. Theriac, of fame a century ago, made of a mixture of everything that tasted bad; asafœtida, of a bad odor, which many of us as children carried in a little bag hung round the neck with a string; strong bitters, stinging linaments, violent physics, repulsive lotions such as "skunk oil" or crushed vermin and patent nostrums of innumerable sorts have in their time rendered "cures."

The Essence of the "Cure."—These cures are possible because at almost any time a goodly number of the cases of psychoneuroses have been relieved of the motive responsible for their symptoms. Being ready for the cure, almost anything which has a wide and startling repute may appear to affect the cure. Where the incentives of the symptoms still persist, patients are rarely cured, at least permanently, but given the moment when the symptoms have lost their function, conditions are ripe for a cure. In these moments it is better to be the subject of a marvelous new cure than merely to throw away the crutches and walk; the latter may arouse suspicion whereas the former carries with it considerable prestige.

Because of these facts, there is wisdom and justice in the coolness with which men of science view the numerous new types of mental cures. The mere fact that apparent cures, even apparently marvelous ones, are wrought is by no means convincing evidence of intrinsic merit. Many of the forms of psychoanalysis, Couéism and other cults, have yet to demonstrate their fundamental validity. They may remove symptoms without effecting a real cure.

Real Cure a Psychological and Educational Problem.—For all types of distorted personalities, the chronic introvert, the sour-graper, the rationalizer, the closed-mind, the subject of unfortunate compensations or de-

fense mechanisms, in degrees mild or extreme, the best remedial treatment consists in reëducation. As principles of guidance in reëducation, Dr. Shepherd Ivory Franz, eminent authority in this field, mentions five requirements:

1. The nature of the abnormality, particularly of the incentives and history, must be specifically known.
2. The patient should be given to understand as well as may be the cause, nature and history of his difficulty.
3. The patient *must wish to get well,* his environment and mental attitudes must be so changed or modified that he will wish to get well.
4. The patient must achieve confidence, that he can and will get well.
5. Beyond these, there must be carried out special steps in reëducation, "not hit or miss," but adapted to the patient's special mental condition, to his previous education, and to the environment in which he has to live, so that he may carry out his life work in the community as part of it.

Study of many of the "cures" and new cults disclose that in one way or another they satisfy one or more, but rarely all, of these conditions. To cure completely, treatment must include all of these steps.

Preventive Measure.

As in other fields of service to ailing humanity, prevention is preferred to cure, education to reëducation. How shall we avoid developing undesirable habits of the kinds here listed and others? One thing we may do is to become familiar with the ways which are right and wrong. We should, then, understand as well as we may the tendencies to idle dreaming, self-pity, rationalization,

not only in general, but our particular susceptibilities and the conditions under which undesirable reactions are most likely to occur. But mere knowledge of what not to do, indeed, knowledge of just what to do, is insufficient. Habits of holding our mental adjustments within proper limits, of thinking impersonally, of compensating wisely, these in numerous particular forms to meet a multitude of specific difficulties must be acquired.

The "moral" of this discussion is contained in a quotation from William James's famous chapter on Habit: "The hell to be endured hereafter, of which theology tells, is no worse than the hell we make for ourselves in this world by habitually fashioning our characters in the wrong way." "The great thing, then, in all education, is to make our nervous systems our ally instead of our enemy. . . . We must make automatic and habitual, as early as possible, as many useful actions as we can, and guard against the growing into ways that are likely to be disadvantageous to us, as we should guard against the plague."

QUESTIONS AND EXERCISES

1. What instincts are frequently thwarted and what adjustments are often made by the following:

   The deaf child
   The crippled child
   The light-house keeper
   The missionary
   The slave
   The youngest child in a household
   The grandmother in a household
   The head of a large business concern
   The office-boy
   The book agent

2. Are animals more subject to thwarting of impulses than man? Consider the case of the truck horse, and of the uncaptured lion.

3. Were the conditions of life under which primitive man lived more or less conducive to mental health than those of modern times?
4. What are some of the signs by which you can discover in a class of children which individuals are prone to make overt and which to substitute mental adjustments to difficulties?
5. An experienced abnormal psychologist wrote that "sympathy blesses neither him that gives nor him that receives." Discuss the validity of this idea in the light of the facts presented in the chapter.
6. Give five historical examples of individuals who compensated in a useful way for the thwarting of instinctive desires.
7. Explain, in scientific terms, the subconscious.
8. Who is the best judge of whether an individual is rationalizing or reasoning, the subject himself or an observer? What circumstances make different answers to this question possible?
9. Show that the mechanism of rationalization is useful in social intercourse.
10. What mechanism is often behind the use of such terms as "bookworm," "grind," "profiteer," "Demagogue" and the "reformer"?
11. Give as many examples as you can of "sour grapes," "projection," and other forms of adjustment. Which do you consider desirable? Which undesirable?
12. We say that a man who resists the prompting of a strong instinctive tendency because it is contrary to the social code, has a "strong will." What do we mean here by the term "will"?
13. A number of authorities have asserted that many "reformers" are motivated by impulses to protect themselves from danger or temptation and that many of the most violent critics are subjects of "feelings of inferiority." Can you develop these notions more fully? Then evaluate their merits and deficiencies.
14. List some of the possible causes of eye trouble which prevent the completion of a required task in school.
15. To what mechanism might the normal individual attribute the activities of martyrs and what could easily be the martyrs' reply?
16. Make a list of the excuses frequently given by students failing to pass an examination and examine them for rationalization.
17. Draw up plans for

(a) A society in which conflicts due to social taboos would be reduced to a minimum;
(b) An environment in which conflicts due to physical factors would be reduced to a minimum;
(c) An organism with no conflicting impulses. How practical are your suggestions?

18. What is the best thing to do when a desire is thwarted?
19. Recall instances of unusual but probably not genuine cures? Explain them. Apply to the usual attitude of people toward cures, the well-known fallacy, "Post Hoc Ergo Propter Hoc" (after, therefore because of).

GENERAL REFERENCES

For further descriptions of mental adjustments consult John Watson, *Psychology,* New York: D. Appleton, 1919, Chapter 11, R. S. Woodworth, *Dynamic Psychology;* New York: Columbia Univ. Press, 1918, Chapter 7, and *Psychology,* New York: Henry Holt, 1921, Chapters 19 and 21; F. L. Wells, *Mental Adjustments,* New York: D. Appleton, 1917; T. V. Moore, *Dynamic Psychology,* Philadelphia: Lippincott, 1924, and B. W. Hart, *The Psychology of Insanity,* Cambridge Univ. Press, 1920.

For a description and an explanation of the psychoneurotic symptoms of soldiers see H. L. Hollingworth, *The Psychology of the Functional Neuroses,* New York: D. Appleton, 1920.

Illustrations of, and guiding principles in, the reëducation of sufferers of various disorders are described by Shepherd I. Franz in *Nervous and Mental Reëducation,* New York: Macmillan, 1923.

The Freudian doctrines are illustrated and explained in Sigmund Freud's *Psychopathology of Everyday Life* (a translation by Brill), New York: 1914. Critical reviews of the Freudian doctrines will be found in Knight Dunlap's *Mysticism, Freudianism and Scientific Psychology,* St. Louis: C. V. Mosby Co, 1920, and A. Wohlgemuth, *A Critical Examination of Psychoanalysis,* New York: Macmillan, 1923.

William James' famous essay on "Habit" is Chapter 4 of his *Principles of Psychology,* New York: Henry Holt, 1890.

CHAPTER X

THE GENERAL LAWS OF LEARNING

In the preceding chapters, several facts were observed which bear upon the nature of learning. In the discussion of the connecting mechanism we noted the tremendous complexity of neurones, particularly those in the brain, which are concerned in learning. We observed that, between sense organ and reacting mechanisms were series of neural connections offering innumerable possible pathways but that the nerve impulse usually takes some limited course. The limiting conditions were found in the synaptic connections, some of which were "open," some of which were "closed." To acquire new reactions means to change these conditions at the synapses, to change the effective connections. In a later chapter we noted the fact that such neural changes are possible, as a result of our original nature. For this reason, it was said that the capacity to learn is a native trait. In the last chapter were given illustrations of some of the dynamic factors in learning, with special emphasis on the rôle of the main urges, likes and dislikes in initiating and subtly controlling learning. The importance of proper habit formation was also stressed. Learning and habit formation is adjustment to the conditions of life, but the kinds of adjustment we strive to make are determined at first almost wholly and throughout life very largely by the character of our fundamental urges. We strive to avoid the annoying and to achieve the satisfying states of affairs, and in thus striving we learn; but what annoy

and what satisfy are largely determined by a number of native and acquired cravings. This does not mean that the habits we form are specifically predetermined by our natures. On the contrary, many habits, both good and bad, may satisfy our cravings to some extent or fully and what is more, our main urges may be modified within limits, by proper training. The present chapter serves as an introduction to the principles to be observed in the task of training one's self or others. First will be presented certain very general laws of learning, principles which hold for every type of acquisition. These will be illustrated anew as we proceed to more detailed considerations and particular rules of economy in learning of various sorts.

We Learn by Reacting.—Of prime importance is the first generalization, namely, that we learn by reacting. Learning takes place only during activity; it is never a passive process of absorption, but on the contrary a very active process of reacting. Acquisitions of the observational or informational type, such as becoming familiar with a face, tree or building so that we can later recognize or recall it, or memorizing names and dates, the spelling of a word, or acquiring information during reading, like the acquisitions of movements and skills, are the result of reactivities. The same is true of learning to control one's temper, or to appreciate music, art or literature; all these are acquired in the process of reacting. In fact, what one learns are reactions; namely, those reactions which, having once been made, are strengthened during further responses.

The Law of Use.

The simplest form of learning consists in the strengthening of native reactions. Exercise of any reaction—

walking, grasping, crying, laughing, becoming angry, sad, or joyous—other things being equal, tends to make that reaction more prompt, more certain, more easy. The use or exercise of any situation—response connection strengthens it; the stronger the connection the more prompt, easy, and certain the response. The use of a connection unit (series of neurones) brings about certain changes, mainly in the synapses, which makes the passage of the nerve impulse more rapid, easy, and complete. This is what is meant by increasing the strength of the connection between a stimulus and a response. Such modifiability of nervous structure is a native capacity which may be expressed by the *Law of Modification by Exercise,* or more simply, the *Law of Use.* It may be stated as follows: *Whenever a modifiable connection between a situation and a response is exercised, other things being equal, the strength of that connection is increased.*

The Law of Frequency.—The Law of Use expresses a basal fact, one that is needed to explain learning of every kind. A necessary correlate of this law is the fact that exercise up to a certain physiological limit is cumulative in effect. If one response strengthens the connection somewhat, then two responses have greater effect than one, three greater than two, and so on *Consequently, other things being equal, the more frequently a connection has been exercised the stronger the connection.* This is sometimes called the *Law of Frequency.*

The Law of Disuse.

Modifications in the nervous system produced by use, however, are not retained in completeness for unlimited time. The nervous changes brought about by disuse are, roughly speaking, comparable to those produced in a muscle. One may by exercise strengthen the muscle to

a high degree of vigor, but the effects gradually disappear with disuse. The gradual forgetting of names, dates, or poetry, the gradual loss of skill in typewriting, drawing, singing, etc., when these functions are not revived by exercise, illustrate this fact. The *Law of Disuse* takes a place with the Law of Use as a well established principle. It may be stated as follows: *When a modifiable connection between a situation and a response is not exercised during a length of time, the strength of the connection is decreased.*

The Law of Recency.—The deteriorations of connections through disuse is a gradual process. One day of disuse causes some loss in the strength of a connection, two days a little more, and so on. The effect is cumulative, a fact often expressed in the correlative *Law of Recency,* which may be stated thus: *Other things being equal, the more recent the exercise, the stronger the connection between the situation and response.*

While the strengthening effect of use is involved in all learning (the weakening effects of disuse being really a passive process), the acquisition of all complex functions such as writing, speech, swimming, reading, learning poetry, involves a great deal more than mere repetition of a number of native reactions. We do not have a feeble writing ability at the start, which by general exercise is made more easy and secure. We have, rather, a very large number of very minute, specific reactions, each to a particular stimulus, many of which are already organized, loosely or firmly, into acts. In the process of learning, some of these are selected and strengthened by use, others are disentangled and eliminated, to die out by disuse; others, possibly to be killed in some more active way. The acquired act of speaking a word, for example, is a compact bundle of specific connections between

minute stimuli and minute reactions, and before the connections are selected, strengthened or weakened and properly fitted together, a tremendous amount of sorting must have been done. In actual learning, then, use and disuse operate upon very specific S-R connections. We do not practice one big writing or speaking reaction as we learn; we select and exercise, with varied vigor and for various lengths of time, hundreds of tiny constituent units.

How Are New Reactions Acquired?

We learn by "hitting upon" a reaction and then exercising it; but how do we "hit upon" the desired reaction? When the child is first given a pencil, he grasps it much as he would seize any small stick; but in the course of time he will have acquired new muscular reactions to this object. How were these new responses achieved? How does it happen that the native or initial reactions, being well established and easy to make, do not continue to occur unerringly? If a child is afraid of thunder, how does he ever get rid of this reaction, since, according to the Law of Use, the more he makes the fear reaction the more firmly it should become fixed. If he does conquer his fear of thunder, what has become of that reaction?

These are important matters that have been deliberately neglected so far. We shall have to attempt an explanation, for the practical solution of many problems to be encountered later depends upon the answer to the question: How are new reactions acquired?

Our equipment for explaining learning now consists of the Law of Use (or Frequency), the Law of Disuse (or Recency), and a complex environment which provides specific stimuli in various combinations. We will proceed to examine representative types of learning, illustrating

the way in which these principles operate, going as far as possible without introducing additional laws.

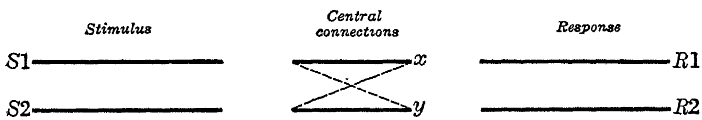
Many of the illustrations following are selected from experiments on animals as well as upon human subjects. It will be interesting and important to observe how adequately the main principles of learning apply to both. In keeping with the Law of Parsimony, we should seek to explain human learning as far as possible by the principles which hold for animal learning; science prefers few rather than many and simple rather than complex explanations.

The Association of Simultaneous Reactions.

New connections are established when two (or more) situations which elicit different but not mutually exclusive reactions are repeatedly presented simultaneously. When an object moves rapidly toward the eye, the native reaction is a wink; when the skin of the finger is stimulated with a slight electric shock the native response is a quick withdrawal of the hand. If the two stimuli are given at once the result is a simultaneous wink and jerk of the hand. If we continue, time after time, to give the two stimuli at once and finally give only one—say the electric shock—the probable result is that both the jerk of the hand and the wink will occur at once. Or, if we move the object rapidly toward the eye, both wink and jerk will occur. Here, then, is a clear case of acquisition; we now have a combination of two responses to a situation which previously gave us only one. Or, to say the same thing in another way, we have acquired new connections: one between the eye stimulus and the hand effectors, and another between the hand stimulus and the wink mechanism. New pathways through the nervous

system have been opened up and strengthened by use (repetition) so that the nerve impulse flows through and produces a new reaction.

The Neural Basis of Associative Learning.—A significant feature of the nervous system is that it provides pathways from each receptor to a tremendous number, very likely, to all effectors (see pp. 66 f.). Of these innumerable connections but few are strong enough to arouse the effectors as the result of ordinary stimulation; the others are "closed" in the sense of ordinarily producing no observable reaction. Actually, then, physical connections between the eye stimulus and the hand muscles, as well as between the hand stimulus and the eyelid muscles must have been in existence to begin with. Let us call the stimulus, movement of the object toward the eye, S1, and the wink R1; the electric shock S2, and the withdrawal of the hand R2. The connections are pictured in the figure below. The heavy line indicates a strong



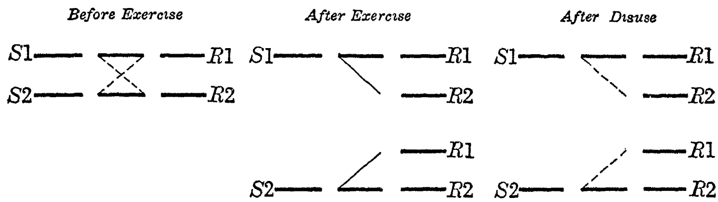
connection, the dash line a weak connection. Although S1 is actually connected with R2 it cannot alone arouse R2 because the intervening pathway (mainly the synapses at y) offers too much resistance. When S2 is stimulated at the same time, the barriers at y are broken down so that the impulse from S1 gets through, discharging weakly at first, into R2, according to the principle of facilitation (see Chapter III). By repetition of this combined stimulation, the impulse from S1, according to the Law of Use, would break through more and more readily. In other

words, the connection between S1 and R2 is gradually strengthened by use until S1 alone is capable of producing the response R2 as well as its original, R1. All of this is true of the S2-R1 connection also.

Characteristics of Acquired Joint Reactions.—By the repeated associations of two situations which produce two harmonious (in the sense that both can occur at once) reactions, each stimulus becomes connected with both responses. To each has been attached a new reaction, in addition to the old one. The object-approaching-the-eye produces a jerk of the hand; the shock produces a wink. Neither of these was made, until the "subliminal" connection (a connection too weak to elicit an actual response) had been strengthened by the combined exercise. Thereafter, either situation produces both responses; and according to the Law of Use, continually to administer one stimulus would further increase the strength of both connections, so that the combined response would occur more surely, promptly and easily. This raises the question as to whether both combinations are identical. No, they are not; for the reason that the connection of each stimulus with its old response always remains stronger. The object-approach-eye stimulus invariably produces a combination in which the wink is more emphatic; the finger shock produces a combination in which the finger jerk is more pronounced. While the reactions in both cases include both wink and finger jerk, it is necessary to think of them as a *joint reaction* determined by the strength of the particular connections between the specific stimuli and the specific responses. The justification for this is seen most clearly if you fail to exercise one of the joint reactions for a while. Fail to apply the shock stimulus for a time and the wink unit of the combination may fail to occur,—it has died out from

disuse,—whereas the withdrawal of the hand, being more strongly connected with the stimulus, still occurs.

The facts may be shown diagrammatically in the accompanying figure.



In the figure the heavier the line the stronger is the connection. The dotted line means a subliminal connection.

Association of Motor Reactions.—When a hungry kitten sees food it will run toward it. If a child displays food, at the same time calling "Kitty, kitty," a sufficient number of times, the kitten will eventually respond to the call alone. When we are breaking a horse, it does not, of course, respond in any way except by pricking up its ears when we say "Whoa." We stop the horse by pulling on the bit and if, at the same time, we shout "Whoa," and repeat sufficiently, the horse will stop eventually at the word. In both of these cases new connections have been acquired. In both cases, the old response to "Kitty, kitty" or to "Whoa" was mainly an awareness of the sound with but little motor response. These responses still persist but occur simultaneously with the new reactions, *i.e.*, running toward the call or stopping at "Whoa."

Association of Emotional Reactions.—Connections with glandular reactions, as well as with motor reactions, may be acquired in this way. To the stimulus, food in

the mouth, a dog responds by secretion of saliva. If at the time food is presented a bell is rung, the animal will, after sufficient trials, respond by the salivary reaction to the bell alone. It is in this way that the human mouth comes to "water" at the sight or smell of food, the sound of the dishes or the dinner bell, or the mere thought of food. Very diffuse organic or emotional reactions may be attached to new stimuli in this way. A man who suffered acute nausea in a room which smelled strongly of camphor finds that later the odor of camphor tends to reinstate the sickness. After a long voyage, during which one has been seasick, the smell of ship or sea or the mere thought of them may turn one's stomach in some degree. Similarly tears, mirth, affection, or minor likes and dislikes may secure new attachments. In these instances, the reaction produced by the newly attached stimulus is not identical with the response produced by the original. It is merely a weakly aroused reaction of the same sort; weakly aroused since it would require a great deal of exercise to make the new connection as strong as the old.

Association in Informational Learning.—Certain types of information are acquired by attachments of this sort. When shown a leaf, the child reacts by becoming aware of the object. If, while showing the object, one says the word "leaf" a number of times, the child will, at length, think of the object when he hears the word alone. Thus he learns the meaning of the spoken word; for the word itself is merely a combination of auditory stimuli, of course, not in the least like the visual appearance of a leaf. Next, we may show the object (or say "leaf") while the child looks at the printed word **leaf.** With sufficient combined repetition, the child now thinks of the object when he sees the printed word. Later the object, a picture of the object, the spoken, written or printed

word, may be coupled with the French words "la feuille" and the two together reacted to until he thinks of the object or, at least, something which stands for the object, when he sees the French words.

Association in Perception.—In actual life, the simultaneous stimuli are not invariably limited to two; indeed, the usual case includes many more, but the principle is the same. It is by the combination of many reactions, for example, that percepts are built up. When a child is first given an apple he makes a good many reactions to the many stimuli which the fruit provides. He becomes aware of its odor, of its color, of its shape, its weight, its taste, etc., by responding to the several olfactory, visual and other stimuli, simultaneously or in immediate succession. The several responses become attached to each of the several stimuli and with frequent repetition of the experiences one stimulus alone may activate simultaneously, to some degree, the several reactions. The apple is thus perceived when only seen or smelled or felt. We become at once aware of it as a combination of such and such tastes, odors, shape, weight, uses, cost, etc. An apple perceived through the sense of touch is not exactly the same as the percept of an apple smelled, tasted or seen. But the perceptual reaction is so quick, and our interest in it so practical, generally, that we do not observe the fine differences. We simply become aware of an apple, neglecting the sensory and other minor details.

The samples of learning so far considered are, of course, acquired by use, once the possibility of the exercise of the new connection is established. The inter-connections in the nervous system make possible limitless additions of connections; all that is needed, apparently, is simultaneous presentation and exercise. If we can attach the wink reaction to a stimulus on the finger or the salivary reac-

tion to the sound of a bell, it would appear that we can attach any stimulus to any response. So we may generalize: *By means of association and exercise any reaction which the organism can make may be attached to any situation to which the organism is sensitive.*

This is an important generalization; but should it be called a law and be put on a par with the Law of Use or Disuse? If we examine the facts closely it will appear that exercise is really doing the work. From the start there existed real but weak (subliminal) connections which were strengthened when the proper combination of the stimuli was provided. We have merely described the results of the operation of the Law of Use under certain conditions; namely, when two (or more) stimuli leading to different but not mutually exclusive reactions are repeatedly presented together.

The Elimination of Connections by Simultaneous Association.

Learning does not consist entirely of the strengthening and consequent addition of effective connections. Weakening and elimination of connections already present is quite as important. A reaction may be eliminated by the simultaneous presentation of two (or more) stimuli which lead to mutually exclusive reactions.

An Experiment with a Perch.—A minnow thrown into an aquarium with a hungry perch will be very promptly seized, since the former acts as a stimulus to one of the strongest of the latter's native food-getting reactions. If a glass partition is placed dividing the aquarium into halves, the perch in attempting to seize a minnow thrown into the opposite compartment bumps into the transparent obstruction. On receiving the bump, the big fish

turns about and swims to the edge of its compartment. Shortly, it darts at the minnow again only to be halted by the same punishment. It will suffer a good many bumps on the first day before giving up entirely, but on the next day fewer bumps are effective; and so on, until after about thirty days, instead of attacking, the perch swims off to the side or engages in other activity. The attack reaction has been, temporarily at least, eliminated. The bump not only blocked the old reaction but set up a turn-about-and-swim-away reaction which by simultaneous association became attached to the old stimulus. When the perch now sees a minnow, the nerve impulse is shifted into the turn-away reaction. This may be shown in a diagram.

An Experiment with an Infant.—An infant while playing with some pets, which it fondled with pleasure, was frightened by a crashing noise. The child, of course, could not fondle the pets and at the same time withdraw in fear. The fear reaction, getting the right of way, put a stop to the caressing of the animal. The interesting thing about this case was that later when the child saw one of the pets he no longer approached it with pleasure but retreated in fear. This was not a combination of two reactions, but a selection of one reaction and elimination of the other. The nerve impulse aroused by the sight of the animal has been shifted from its old course into another. The fear has been substituted for the fondling reaction. So far as the mechanism of association

is concerned, this case is quite like the previous one, as shown in the accompanying diagram.

The elimination of the attack on the minnow by the perch might be explained by the simultaneous introduction of a stimulus (the bump from the glass partition) which proves an effective block and which also sets up a mutually exclusive or "incongruous" reaction—the turn-away. In the case of the child who acquired a fear-and-retreat reaction on sight of the animals, there is scarcely a blocking of the original response of approach, although there is introduced an "incongruous" reaction. That is, the child cannot simultaneously approach-to-caress and withdraw in fear. The latter reaction wins out conceivably because it is stronger and by means of association becomes attached to the stimulus which originally led to the incompatible response of approaching-to-fondle.

Elimination Without a Blocking.—Responses are eliminated, however, when no block or obstruction or other stimulus is present to set up an incongruous reaction. A famous experiment, performed by G. W. and E. G. Peckham, will serve as an illustration. These observers found that a spider dropped hurriedly from its web at the sound of a tuning fork. When it had climbed back, a repetition of the stimulus produced the same dropping reaction; but after eight or nine trials the stimulus suddenly lost its power; the spider failed to react by dropping from the web. Next day, however, the stimulus was effective for a time but failed after six or seven

repetitions, and after about ten days the dropping reaction ceased entirely—at least for a time. In this experiment the spider's reaction was in no way blocked; no pain was involved; no definite incongruous reaction was set up. The connection between the sound of the tuning fork and the response of dropping, which was at first prompt and certain, had been gradually stamped out.

Limitations of the Laws of Use and Disuse.

This is really a most curious matter. The dropping-to-the-ground reaction had been eliminated in the very process of exercise. According to the Law of Use, the tendency to drop at the sound of the tuning fork should have been strengthened; should have become more prompt and certain. Instead of that, it gradually became less prompt and certain, finally being eliminated entirely.

This phenomenon might well bring the Law of Use under serious suspicion. This experiment, however, does not really discredit the Law of Use but portrays one of its limitations. Exercise is a true and faithful servant of learning, but it is unable to do all the work alone. In fact, all along we have been neglecting another and possibly more powerful factor, one which we must shortly bring forward. Before so doing, it will be advisable to present a few more illustrations of the inadequacy of the Laws of Use and Disuse, in which the new factors, which contribute to the control of learning, are more clearly portrayed.

Illustration from Study of Rats in a Maze.—For one investigation, a box was constructed in such a way as to offer to a rat placed in a certain compartment four different avenues of escape, all of which led to food. The box is pictured in Figure 32. One way led through a small compartment in which the rat always received a slight

electric shock as he passed; a second led to a similar compartment, in which the rat was confined for twenty seconds before being permitted to proceed; a third led to a long pathway to be traversed before food was reached;

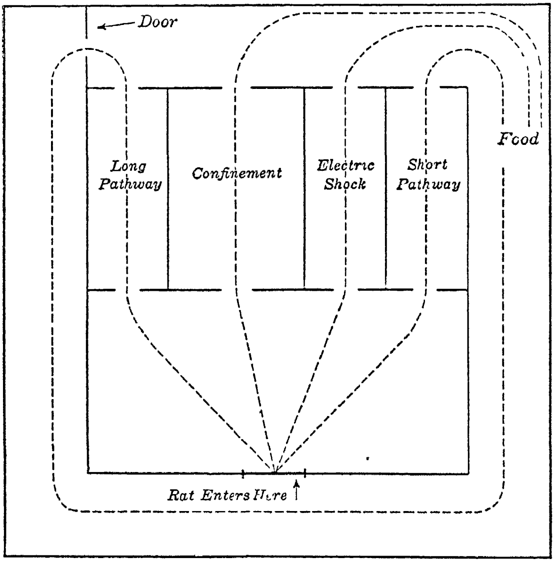


FIG. 32—THE EXPERIMENTAL COMPARTMENT BOX SHOWING THE SEVERAL ROUTES. In the actual experiment the compartments were rearranged for different groups of rats, i.e., for one group "confinement" would be situated on the left, for another in the second position, as pictured above, for another in the third position, and for another on the right. Thus no type of "effect" was given the conceivable advantage of a favorable position. Movable doors were also provided to force the rat in the direction desired after emerging from the compartment. (After Kuo. *Journal of Comparative Psychology,* Feb, 1922.)

and the fourth compartment provided a short pathway directly to the food. The positions of the four little compartments were so arranged that a particular rat, on his first trial, was as likely to enter one as another; so, by using a number of rats, it was possible to ascertain the

factors which guided choice. Each of thirteen rats was given trials until it had finally selected and thoroughly learned one of the four ways.

At first, a rat was as likely to take one way as another, with the result that in the first four trials each way to the food was practiced equally often, approximately. But soon all had given up the pathway which produced the shock. A little later all had refused the way which produced the twenty seconds of confinement. The long way was eliminated more slowly; but finally all but two went by the short route. Now, by the Law of Use alone, an equal number should have learned permanently to go by each route, since each was chosen and exercised equally often at the beginning. But the fact was that the exercise which brought pain failed to be effective; the rats soon gave up that route. Practice of the route which brought confinement was more effective; but finally that route was eliminated by the whole group. Use of the round-about pathway was likewise insufficiently effective, since with the exception of two rats all gave it up, although they relinquished this pathway less promptly than they did the first two routes.

Illustration from Behavior of Cats.—Another illustration, similar in principle, may be more clear. Suppose that after five cats have been taught to come to the call of "Kitty, kitty," each is called singly, and No. 1 is given food and later caressed, No. 2 is caressed only, No. 3 is totally disregarded, No. 4 is sprinkled gently with water, and No. 5 is douched with water. Assuming that all have just learned to respond to the call and that other conditions such as hunger, fatigue, the satisfaction occasioned by the activity under way at the time called, etc., are approximately equal, they should all learn to come more promptly and surely by virtue of exercise, as they are

repeatedly called. But will they? Cat No. 1, which was fed and petted, will probably come more and more surely and promptly; No. 2, which was merely petted, will probably continue to come but not so promptly as No. 1; No. 3, which was entirely disregarded, will probably continue to respond for a while, but less promptly and frequently, finally failing altogether; No. 4, which was sprinkled, will probably give it up more quickly than No. 3; and No. 5, which was douched, will probably very promptly show a failure to respond.

The Influence of the Effect of a Reaction.—There is no doubt about it: influences other than exercise are at work here. Very potent influences they must be to nullify and augment the results of exercises as they do in the illustrations just given. Apparently there is something about the *effect* which accompanies or follows an act that either reinforces or decreases the results of use or causes an animal to repeat the act in one case and avoid it in the other. Pain, confinement, the holding up of a tendency under way, futile or wasteful work all tend to stamp out the reactions which they accompany or follow. On the other hand, reactions which bring release from confinement or pain, which bring food, kindly treatment, or attention, are repeated and stamped in more rapidly than when they are exercised with an indifferent result. It is the reaction which gratifies some strong urge, which brings a satisfying state of affairs, absolute or relative, that is repeated and stamped in quickly during use. The more satisfying the resulting state the more surely the reaction will be repeated and the more quickly stamped in. On the other hand, those reactions which are avoided or are stamped out even during the process of exercise, are the ones which thwart some insistent urge, which, in other words, are accompanied or

followed by annoying states of affairs or annoying effects.

The fact that human beings as well as animals tend to repeat and learn those reactions which, broadly speaking, bring a satisfying state of affairs, whereas they tend to avoid, and therefore fail to repeat and learn those reactions which bring an annoying state of affairs might be illustrated at length. We shall give only a few typical examples.

An infant lying in its crib is disregarded by its mother and her guest. Soon the child begins to cry and scream. The women rush to the baby, pick it up, fondle and pet it. Treatment highly satisfying to the child is thus associated with crying and screaming. Similar experiences follow on many occasions, and when the child has attained several years of age it still sets up a great racket if it is disregarded or uncomfortable. The tendency to cry and scream in such situations had been built up by the satisfaction of attention which it had always brought. One child, age eight, had developed a habit of persistent "begging" when its mother said "No" to its requests, whereas a neighboring child of the same age took "No" as final without further whining or whimpering. Both had in earlier years repeated their demands after the first "No," but the mother of the first child, perhaps to avoid being bothered, frequently gave consent sooner or later, whereas the other mother did not change her decision. A child learned to use a "naughty" word on the street because it was taught and applauded by some "nice big boys," but its use at home was stamped out because it brought a scolding, or perhaps better, total disregard. Attach satisfaction to any response and it will be learned; attach annoyance and it will drop out.

The Nature of the "Effects" of Reactions.—The terms "satisfying" and "annoying" states of affairs were just

used to indicate the general nature of the "effects" which accompany or follow reactions and greatly influence learning. In the case of the human subject, these effects are recognized as equivalent to the feelings, *pleasantness* and *unpleasantness* first described in Chapter VI. In man the "satisfying" state of affairs is accompanied by the feeling of pleasantness; the "annoying" state of affairs by unpleasantness. The feelings, it will be recalled, are conscious states; they are due either to some organic reaction or to some subtle condition in the neurones—any neurones—themselves. In animals everything indicates that certain states of affairs are maintained, cherished or sought quite like those which are pleasing to men and that others are avoided or rejected as the unpleasant states of affairs are by men. Can we say that animals experience feelings of pleasantness and unpleasantness like our own? We cannot, of course, since we are unable to delve into their conscious states. The terms satisfying and annoying states of affairs or effects have been used to cover observed positive and negative adjustments both in men and animals. When used, they do not necessarily imply the conscious feelings. In the case of humans, however, it is taken for granted that the satisfying effect is consciously experienced as pleasant, the annoying as unpleasant. Satisfying and annoying are broader terms.

The Law of Effect.

We now need a general statement to cover the observed facts concerning the influence of the effects of a response upon the individual's future behavior. We need one or more generalizations that will embrace the facts in a simple yet faithful way. The following statement seems

to be satisfactory: *The individual tends to repeat and learn quickly those reactions which are accompanied or followed by a satisfying state of affairs. The individual tends not to repeat or learn quickly those reactions which are accompanied or followed by an annoying state of affairs.* These statements constitute the Law of Effect.

How Satisfying and Annoying Effects Work.—The influence of the satisfying or annoying state of affairs may be that of a selective agent. When the individual is annoyed by a reaction, he tends to avoid that reaction in the future and consequently does not acquire the reaction through exercise. When the individual is satisfied, he is attracted rather than repelled by the stimulus; he tends to repeat the same reaction which is consequently stamped in or learned. It may be that the satisfying and annoying states of affairs exert their influence entirely by way of the general orientation to approach-and-repeat in the one case and to avoid in the other. This explanation seems to be adequate to cover most, if not all, of the facts observed in experimental studies and in the activities of everyday life.

Thorndike, in his pioneer work on animal learning, was led to ascribe more far-reaching effects to satisfaction and annoyance than a mere general orientation or selective tendency. He was inclined to believe that "satisfyingness" and "annoyingness" were intimately associated with the subtle changes in the neurones themselves, which in one case intensify or further the effects of exercise and in the other reduce or nullify them. These hypotheses are contained in the following quotation: "When a modifiable connection between a situation and a response is made and is accompanied or followed by a satisfying state of affairs, its strength is increased: when made and accompanied or followed by an annoying

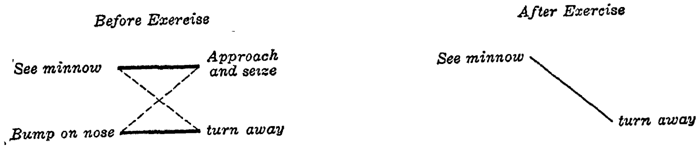
state of affairs, its strength is decreased." That is, the *effects* of exercise influence the neurones in the one case in a way favorable to strengthening the connections and in the other case in a way to weaken the connections. Just what the inner results of satisfyingness and annoyingness are is not as yet known. This fact cannot be urged against the theory, however, since there is similar lack of information concerning the neural changes brought about by use and disuse, whose efficacy is universally admitted.

While the precise mode of operation of satisfying and annoying states of affairs or effects is not known, there can be no doubt about the validity and necessity of the first generalization, namely, that individuals tend to repeat and learn quickly those reactions which are accompanied or followed by satisfaction or pleasantness; and they tend not to repeat those reactions which are accompanied or followed by annoying states of affairs or unpleasantness. The *effect* of a reaction thus tends to determine what connections are acquired or eliminated.

Applications of the Law of Effect.

Illustrated by the Perch Experiment.—A little more attention must be given to the matter of elimination of connections, now that we have the Law of Effect to apply, because it has some important implications for learning, particularly when we are dealing with very strong tendencies. Let us recall the experiment with the perch. When the perch received the bump on the nose he turned about and swam away. The annoying effect of the bump weakened the tendency to attack until finally, when the perch observed a minnow he turned away instead of attacking as before. The turn-away

reaction has been substituted for attack, as shown in the accompanying diagram.



What happens to the old reaction—that of attacking a minnow when it is seen? Since it is no longer being exercised, it is of course dying out, according to the Law of Disuse. But so strong a tendency as that of a fish to seize its food takes a long time to die out from mere disuse. Many acquired reactions, which are probably less deeply imbedded in our nervous system, will scarcely die out from disuse in the course of a lifetime. If you could, by some miracle, refrain from saying, thinking, or otherwise using your name, how long would it be before recall would be impossible? Certainly a very long time, probably more than fifty years. So the perch's tendency to seize minnows is still in existence but, for the present, another reaction is taking its place, namely, the tendency to turn away—a reaction originally made to the bump on the nose but now made directly to the presence of the minnow. How long will this substitute reaction keep up? Just so long as it remains stronger than the other tendency. But actually in this experiment the perch gradually lost the turning-away reaction and went back to his old trick of seizing the minnows. Why? Because the substitute reaction, although exercised, produces no satisfying effect. On the contrary, it becomes annoying and thus its strength is reduced until the old reaction gets the upper hand.

Illustrated by Human Behavior.—These facts may be illustrated by observation of human behavior. A child is natively self-assertive—so forward and boastful that the parent in an attempt to break his tendency demands, on each outbreak, that the child sit quietly and silently for five minutes. After this has been done several times, the situation which previously elicited a boastful outbreak now tends to produce cautious remarks because of the effect of the earlier punishment. With no outbreaks, of course, goes no further punishment and as time goes on, the holding in of the impulse to boasting becomes annoying, until finally the old reaction breaks out again. One cure for it is further punishment; but there is another way of dealing with the situation, namely, by making the substitute reaction satisfying.

If the perch, when it turned toward the side of the aquarium after the bump, had been given food and similarly rewarded on each succeeding instance, it would eventually, on seeing a minnow, promptly turn to the side where it was fed. If the child had been greatly satisfied by praise or some other reward whenever it refrained from unseemly self-assertion, the more modest reaction would have been gradually built up through exercise and effect where exercise alone might have failed. Here then is the essence of eliminating undesirable tendencies; start the desirable substitute reaction somehow, by punishment if necessary, but build it up by making it satisfying.

Forms of Satisfying and Annoying Influences.—Social disapproval, harmless deprivations, and other annoyers may do as well as physical punishment. Any stimulus that will elicit the desired substitute reaction is what is needed. For example, in attempting to "break" the child of fear and crying during thunderstorms, scold-

ing, threats, or other punishments only make matters worse. Show an interest in the lightning, call attention to its novelty and beauty and thus substitute for the undesirable reactions curious observation. When you get that, or some better substitute, reward it by praise. It is thus by the proper manipulation of satisfyers and annoyers as well as by practice that the course of learning may be most effectively directed.

How to Utilize Satisfying and Annoying Effects.—Two additional facts should be taken into account in utilizing satisfiers and annoyers. The first is that the effects of either become greater the more closely it is associated with the reaction in time. To be really effective, satisfiers and annoyers must accompany the reaction or at least follow it promptly. If long delayed they may be ineffective or they may become attached to an entirely different reaction. The second fact is that satisfiers and annoyers differ in degree or intensity and that the greater the intensity up to a certain limit, the greater the effect on learning. Food for a hungry cat is a more intense satisfier than petting; a bucket of water dashed on a cat is a more intense annoyer than a sprinkling. What states of affairs satisfy and what annoy human individuals was disclosed in a measure in the studies of the dominant human urges.

Summary

1. Exercise always means reacting.

2. Other things being equal, when a reaction is made to a stimulus the strength of the connection is increased. The increased strength is due to modification of the mechanisms, mainly the neurones involved. Increased strength of a connection makes the response more easy, prompt, and certain. This is the Law of Use.

3. Other things being equal, a period of disuse results in the weakening of the connection between the stimulus and the response. This is the Law of Disuse.

4. Reactions which are accompanied or followed by a satisfying state of affairs are more likely to be repeated and, consequently, learned. It is possible also that satisfying exercise strengthens the connection more rapidly than exercise alone. Reactions which are accompanied or followed by an annoying state of affairs are unlikely to be repeated and, consequently, unlikely to be learned. It is possible, moreover, that annoyingness tends directly to weaken the strength of connections, and thus to eliminate reactions.

5. New S-R connections may be formed when two (or more) stimuli which elicit two (or more) compatible reactions are repeatedly given simultaneously. This is possible because exercise and effect strengthen connections that were already in existence but were too weak to operate. Each stimulus may now produce both reactions, each with a degree of certainty and vigor that is dependent upon the strength of each particular connection.

6. Annoyingness may result in the elimination of one or more existing connections. Thus, a cat which has learned to come to the call of "Kitty, kitty," will eventually fail to respond if it is punished or disregarded when it does come.

7. A connection may be mechanically eliminated (at least temporarily) when two stimuli, which lead to mutually exclusive reactions, are repeatedly given together. Thus a retreat reaction, which is set up when the perch, attacking a minnow, is bumped on the nose, may become attached to the old stimulus. Whether such a substitute reaction persists or not depends upon further exercise and effect.

8. The most effective way of eliminating an undesirable response is somehow to set up a desirable substitute which, to be perpetuated, must be made more satisfying than the original undesirable reaction.

QUESTIONS AND EXERCISES

1. Using the summary of the chapter as an outline, fill in from memory as much of the concrete evidence as you can.
2. In what respects does the substance of the chapter constitute an enlargement of the statement "We learn by doing"?
3. Compare the activities of a child learning to say "kitty" with those of a man trying to avoid some painful state of affairs, as described in Chapter IX.
4. Give some illustrations of the attachment of a new stimulus to a response by association. Diagram it.
5. Give some examples from everyday life of the detachment of a reaction from its stimulus produced by an annoying effect.
6. Give instances of teaching children in school or at home in which the law of effect is ineffectively used or neglected or cases in which bad impulses are actually rewarded.
7. What, primarily, determines what shall satisfy and what shall annoy?
8. Can you give cases where punishment for poor work has led to a dislike for that task or for work in general?
9. Apply the Law of Effect to problems of developing efficiency and content among employees in some type of work.
10. Apply the Law of Effect to the grading, return, and display of examination papers. Should papers be returned promptly? Should you emphasize errors only? Should you expect perfection and take it for granted without commenting on it? Should you list the names of the 10 best or the 10 poorest pupils?
11. How should you proceed to help someone break the habit of smoking? Pitying himself? Getting the "blues"?
12. What might be the effect of punishing a child by making him stay in after school to write all misspelled words 20 times each?
13. Defend or criticise this statement: "The Law of Effect is the most important law of learning."
14. How would you explain learning to disregard the noises in a school room or work room, impulses to play during working hours, or the tendency to feel "hurt" when criticised?
15. If there were no Law of Effect would the learning of an individual be more or less at the mercy of the environment? In what ways would we have to change methods of teaching?
16. If it were not possible to strengthen new connections by simultaneous association, could any learning take place?

17. Suggest the most effective methods of securing the following results: (a) Break an adolescent of the habit of "baby-talk"; (b) break a habit of saying "he don't"; (c) teach a dog not to chase cats.
18. Give a plausible account of the development of the following behavior: (a) a child refuses to go to sleep unless the mother sits by the bed; (b) a woman gets a headache when she thinks of doing a batch of sewing; (c) a child refuses to eat unless permitted entirely to choose his own food; (d) a man fumbles a button on his coat whenever embarrassed.

GENERAL REFERENCES

William James, *Psychology: Briefer Course*, New York: Henry Holt, 1892, Chapter 16; E. L. Thorndike, *Educational Psychology*, New York: Teachers College, 1913, Vol. II, pp. 1-84; R. S. Woodworth, *Psychology*, New York: Henry Holt, 1921, Chapter 16.

REFERENCES TO STUDIES UTILIZED IN THE TEXT

H. Cason, "The Conditioned Eye-lid Reaction," *Journal Experimental Psychology*, 1922, pp. 153-196.

J. B. Watson and R. Rayner, "Conditioned Emotional Reactions," *Journal Experimental Psychology*, Feb., 1920.

N. B. Triplett, "The Educability of a Perch," *American Journal Psychology*, 1901, p. 354 ff.

C. W. and E. G. Peckham, "Some Observations on the Mental Powers of Spiders," *Journal of Morphology*, 1887, p. 383 ff.

Z. Y. Kuo, "The Nature of Unsuccessful Acts and Their Order of Elimination in Animal Learning," *Journal Comparative Psychology*, Feb., 1922.

CHAPTER XI

CHARACTERISTICS OF HUMAN AND ANIMAL LEARNING IN COMPLEX FUNCTIONS

Learning, as we observed in the preceding chapter, consists in the strengthening and weakening of connections between situations and responses. When two or more stimuli operate at once, new connections may be formed in the sense of being strengthened from subliminal to functioning strength by means of exercise and effect, and old connections may be eliminated in the sense of being supplanted by new connections attached to the same situation. In general, then, all learning may be said to consist in the addition and subtraction of working S-R connections. The acquisition of any new complex is the result of a great many additions and subtractions of connections, and each change is brought about in the ways illustrated in the preceding chapter.

Several conditions are needed to provide a typical illustration of complex learning. First, there must be some stimulus to arouse the organism to activity. The stimulus must either produce an annoying situation which the animal attempts to avoid (hunger or confinement would be a sample) or an urge for or impulsion toward some consummatory reaction. Thus hunger, itself a response to a bodily condition, may arouse an urge to secure and eat food. These conditions are necessary, otherwise the animal would settle down comfortably with the result that nothing is learned. Second, the

animal must be confronted by a complex situation comprising many features (or stimuli) to which it may react. Third, the successful reactions, in the typical case of complex learning, must be not as yet habituated. With these conditions fulfilled, the operations of the Laws of Exercise and Effect may be observed, resulting, as they may, in the weakening or elimination of certain connections, the selection and strengthening of others and the combination of responses into various types of combined reactions.

In this chapter several types of learning will be illustrated with some attention given to their similarities and differences; the learning of animals will be compared with that of man; and the amount, rate, limit, and permanence of learning will be treated in a general way.

Trial and Accidental Success in Learning.

Learning the Way Through a Maze.—If an animal can learn at all, it can learn its "way about." A maze, consequently, is a useful device for studying learning. By using labyrinths of varied difficulty it is possible to get a rough measure of the learning capacity of different species.

Usually, mere confinement in a maze is sufficient to arouse the animal to activity, but often food is added as an incentive; the animal is rewarded by finding food at the end of the correct course.

A worm, a small chick, or a turtle can master a simple maze; but a rat, which is able to learn fairly complex pathways, is more frequently used in experimental work. Placed in a maze, as shown in Figure 33, the rat begins to nose about cautiously. He explores here and there, sniffing at everything as he goes. A human subject would study the features encountered, with his eyes

rather than his nose. After going into a blind alley, the rat explores it thoroughly before coming out. If it receives a slight electric shock on reaching the terminus of certain blind alleys, it scampers out and very likely moves on or possibly retraces its steps to the more fa-

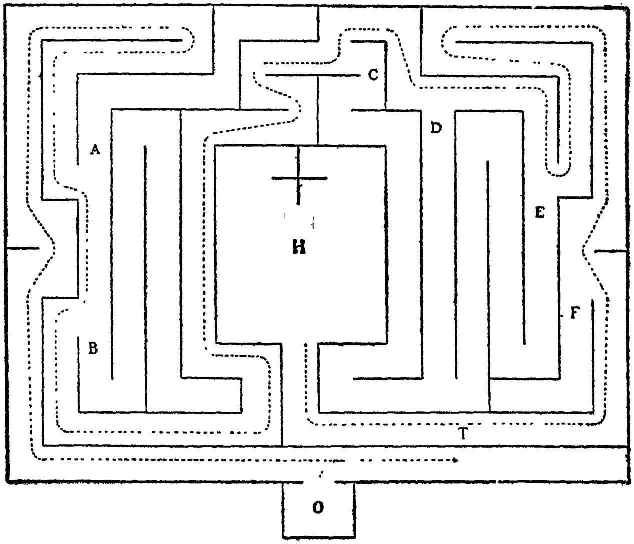


FIG. 33.—THE HAMPTON COURT MAZE, FREQUENTLY USED IN STUDYING THE LEARNING OF RATS AND OTHER ANIMALS. The animal is admitted at O. Food is placed at H. The dotted line indicates the direct pathway; A, B, C, D, E, F indicate blind alleys. (From Watson's, *Behavior*, p. 103.)

miliar territory already covered. After a time, it will venture again, and perhaps after many errors eventually finds its way through the maze to the food box. During a second trial, the rat works its way through the maze cautiously as before, but with fewer entrances into blind alleys, especially those wherein the shocks were experienced. It takes many trials, the number depending in part on the complexity of the maze, before the rat, by

a gradual process of elimination of annoying errors and acquisition of satisfying correct reactions, is able to follow the proper course unerringly. The rat has now acquired a series of reactions which with reference to the features of the maze situation are new. So far as one can observe, the learning process consists of:

(1) The making of reactions, native or previously acquired, to the features of the situation, *i.e.*, old reactions which constitute the "trials";

(2) The gradual elimination of the annoying errors, *i.e.*, the old or trial reactions which bring painful shocks or which end in failure to relieve the confinement;

(3) The gradual stamping in of the reactions which were satisfying because they furthered the animal's progress toward escaping confinement and reaching food;

(4) The linking together of the various successful reactions into what appears to be essentially a unit, embracing all of the several steps or constituent reactions.

An outstanding characteristic of such learning is the great number of "trial" reactions and the numerous errors which occur before the animal hits upon the successful responses. The animal at first makes an enormous number of reactions, and the process of elimination and selection is gradual. Even when the correct series of steps have been made, trial and error are still found, sometimes of a sort too subtle to be readily observed. Tiny errors are still being made and eliminated; very minute improvements are constantly being achieved. The progress of learning is not steady; the number of errors made or the amount of time taken gives a zigzag *curve of learning* as illustrated in Figure 34. This type of learning is described most frequently as *"trial and error"* learning, but perhaps more adequately as learning by *trial and accidental success.*

How Human Subjects Learn a Maze.—If a college student is given a maze to solve which is as difficult for his species as the one described is for rats, the general process of learning will be the same. Hunger or annoyance at confinement may not be required to arouse his activity and thus make learning possible, but some motive—the desire to accomplish something, to learn something, to display ability, to get through with a prescribed experiment—must be invoked. Once under way, the student proceeds until an error is made, whereupon he retraces his steps and goes ahead again. If he receives an electric shock in some blind alley, he, like the rat, is likely to eliminate that error early.

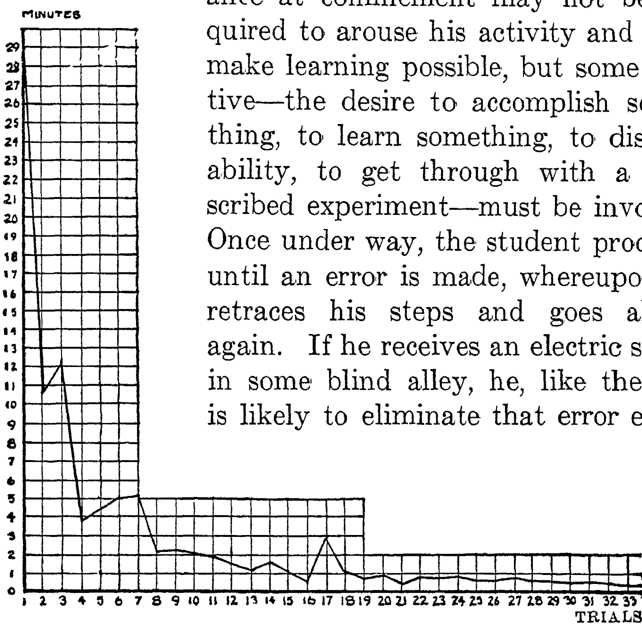


FIG. 34.—A CURVE OF LEARNING THE HAMPTON COURT MAZE (SHOWN IN FIG. 33) BASED ON RECORDS OF FOUR RATS. The vertical column of figures at the left indicates the time required for the trials, which are numbered along the base of the figure. (From Watson's *Behavior,* p. 211.)

When he has completed the maze, several more trials are required to establish the new, successful reactions firmly. The general features of the learning of men and rats are thus the same; only in certain particulars do differences appear.

The human learner makes good use of his vision, in which he is superior to the rat. If the human learner

is blindfolded, he is tremendously handicapped. Man probably has some advantage in the modifiability and retentiveness of his nervous system, that is, any reaction made has a greater effect; it is "stamped in" or "stamped out" more readily. If he notices a sign on the right way or gets a shock in the blind alley, these experiences are retained better. The human learner also indulges to a greater extent in mental activity. By means of memory, he can represent or recall some of the situations and the responses which he made to them. Arriving at an intersection of paths, some sign—the look of the place—may enable him to recall the alley and what he did in it at the last trial. Man, more than the animal or even the child, stands at the crossway and contemplates, and thus often saves energy, time, and errors. The animal and the child keep on the move and usually make more errors. But the memories or ideas of the man add nothing to the general character of the process. They are trials and may lead to error or success, just as the animal's actual movements do. The ideas are merely substitutes for actual observation and movement.

A Comparison of Memorizing and Maze Learning.— Let us examine a case of learning in which overt bodily movements are but slightly involved; one which is mainly observation and recall, but otherwise similar to the maze experiment. Memorizing a series of "non-sense" words is a case in point. The subject is given, a series of twenty words like the following:

> nup, tib, nult, remp, zuc, ralt, marb, selz, kib, curg, toq, sor, dit, quos, viz, pelm, rulb, onk, qat, arz.

Such a list is by no means learned through sheer impression, absorption, or repetition. While the learner may not always realize it, the process comprises false starts

and stops, errors, confusions, the addition of connections, elimination of connections—all of the features of learning a maze.

A typical attack by an efficient learner would be somewhat like this: First, a reading of the series for purposes of general orientation; next, perhaps careful observation of the first and second syllables and possibly the last two —nearly always these are learned first. Then the whole series may be broken up into units or "feet." The first foot may contain *nup, tib, nult* and be read with a rhythm such as followed by similar groupings. The first syllable in each of these groups may be observed with special care. The learner may note and try to remember that the last word of the first group, *nult,* has four letters, and that it is followed by another, *remp,* with four letters. However, he may discard this when he finds that *tib-nult* may be combined into a word that sounds a little like a town he once visited, and this in turn may be discarded when he observes that *nult* almost rhymes with *ralt,* which occupies a similar metric position. A word like *quos* is thought of as "such a mouth full"; whereas *viz* is "buzzy" and *dit* is short and snappy. *Selz* is remembered because it is short for "seltzer." Learners usually keep an active lookout for meaningful reactions and this is trial and error in its clearest form. Suppose, for example, that you see how many meaningful associations you can make with *gip?* Note how you try, one after another, a great many ideas—some satisfactory, others unsatisfactory.

On the whole, memorizing a series of words, far from being a mere passive, mechanical process of repeating one syllable after another, is highly active—or reactive—and presents all of the features of other trial-and-error learning. The good learner is actively observing and search-

ing for clues. He tries reacting by possible meanings, possible sounds, possible combinations with other words, possible similarities or contrasts. Many of these are tried out only to be discarded; others are selected; and before the list is learned the path is strewn with discarded trials. What is finally learned may be called roughly a series of reactions, just as the trip through the maze was a series of reactions.

In memorizing, just as in learning a maze, one attains the first successful trip through the series after many trials, and even with that achievement much remains to be learned by further practice. There are recurrences of difficulties and errors—the curve of learning is zigzag, like that of the rat's in the maze.

Trial and Error in Complex Learning, Typewriting.—Learning the way through a maze and memorizing a series of non-sense syllables are relatively short tasks, at least for human subjects, although it would be possible to make them so long and difficult as to require weeks of effort. Many of the more familiar functions such as reading, writing, drawing, singing, playing the violin, running the typewriter, diagnosing disease, writing poetry, etc., etc., require years of practice to achieve a high degree of proficiency. About the best illustration of the character of learning in such complex functions is afforded by studies of typewriting (as made by Book and others).

If the subject learns by the touch method, he starts to work as follows: Looking at his copy, he finds the first word "what" and thinks of "w." He now looks at a picture of the keyboard, locates "w," and then, finding a corresponding position on the actual keyboard (the letters of which are covered), he makes a stroke. The same procedure for "h" and "a" and "t." After a time, the

task of looking at the picture of the keyboard is eliminated, first for a few and gradually for more letters. The process then is: see the word, think of the first letter, "w," think of its position on the mental picture or representation of the keyboard, locate its position among the keys, and strike. The keyboard has been reacted to consciously (by observation) until it may be represented mentally; *i.e.*, it has been memorized. Of course this is a gradual process so that prior to complete mastery there is an overlapping; some letters may be recalled, while others must be looked up. Needless to say, writing at this stage is very slow and errors are frequent. Shortly the learner finds that the mental image of the position of the keys is unnecessary for certain letters; they may be thought of as on the board. Later, it becomes unnecessary to *think* of the position of certain letters at all. Merely seeing the letter to be written acts as a stimulus to carry the hand and finger to the right spot. The elimination of the several mental steps results in a great saving of time, energy, and usually, of errors. While there has been great progress, however, in respect to the elimination of many useless acts and the perfecting of the finger work in striking the keys, the learner is still in the "letter stage," making a particular complex reaction to each letter.

Further eliminations and selections, almost too subtle to be observed by the experimenter or to be appreciated by the learner, result in a combined reaction to two letters. For example, when "what" is observed, the thought of the "wh" sets off two strokes as if they were a unit; the same for "at" and for other similar units that are frequently encountered. While this unification is spreading to less familiar combinations, longer units such as "are," "The," "ter"; and soon "they," "ough," and later

whole words or even phrases are written as integrated or unified acts. The transitions to broader units are made at different stages for different words; the easier or more frequently used first, the more difficult or infrequent later.

Meanwhile speed and accuracy have been steadily but irregularly increasing. Numberless futile reactions have been discarded. At first the learner may grit his teeth, press the table with his knees—literally write all over. These reactions are gradually eliminated as are more subtle irrelevant errors which result in hitting too hard or too easy, in missing the keys, or timing badly so that the keys clutter frequently. Periods of emotional upset, anger, chagrin, despair, disgust, great elation, and the like are very common at first, but are brought under control. In learning to typewrite, one must learn to adjust his emotional as well as his motor mechanisms to the situation. The elimination of conscious reactions, actual thoughts or images of positions—particular letters, particular movements—goes on similarly. In the expert stage there are, then, relatively few irrelevant reactions. All of the movements become integrated; that is, they become combined into what is essentially one complex action. Attention need be given only to one phase of the process and with increased mastery less and less attention or only occasional attention is required.

The Rôle of Ideas and Observation in the Learning of Man and Animals.

Learning by Purely Mental Trial and Accidental Success.—In the illustrations given, the learning of animals and man is about the same except that the human subject learns more rapidly, retains better, masters more complex functions, and utilizes to a much greater extent

ideas as a substitute for actual manipulation, walking or other motor responses. While not changing the fundamental *trial and error* character of the learning process, the use of ideas, making "trial" reactions mentally instead of overtly, is of very great value usually. It is of value not merely because it saves time and energy, but for other reasons, some of which may be explained more intelligibly later. At this point, a few important advantages may be described. The first is the possibility of practicing in the entire absence of the situation.

It is very characteristic of a man learning to drive an automobile, play cards, or build a house to keep on working at it in "off hours" during the process. He recalls to mind the position of the gears, brake and throttle; mentally he turns on the ignition, adjusts the levers, shifts gears, turns corners, stops, backs and so on. He may picture his "hand" in cards, make plays, visualize the results; in building the house he mentally places the staircase here, the fireplace there and then contemplates the results from various angles. In these operations, he makes trials, detects errors and observes successes. It is an interesting armchair type of learning, tremendously labor-saving and by no means futile. One of the notable features is the possibility of getting down to essentials, of avoiding disturbing or irrelevant details. When actually driving the car, for example, obstructions in the road, the need of steering, disturbing bumps and fears interfere with concentration on shifting gears. Lying abed in the morning, one may get right down exclusively to the matter of shifting the gears, repeating the operation time after time. Such practice really carries over to some extent but rarely fully. Mentally shifting gears clarifies the mode of procedure but does not increase specifically skill in the muscular operations. A fine move in cards,

or "idea" about the position of the staircase in the house may be put into effect easily, but often we find that some essential has been overlooked, we forget the possibility of some one being out of suit and "trumping" or the fact that the staircase position interferes with the light inlet. Even so, mental trial-and-error learning is of tremendous value in point of economy and efficiency, much more in some functions than in others. By virtue of these capacities, man has a great advantage over the animals that do not utilize ideas much if any.

Learning by Observing Others Perform.—The human learner is often able to acquire methods of procedure and detect erroneous and successful moves by observing others perform. Take a knife, cut a piece of elm, strip the bark, make a few notches in the wood, replace the bark with a slit in it and a gust of air properly applied produces a whistle. A group of small boys having observed these operations could go and do likewise, although they often observe incompletely and wrongly or forget what they perceived.

Animals seem almost never able to learn by observation the tricks they can readily learn by trial and error. In performing experiments on animals, one must be sure that the animal observes another's performances, that it then attempts to learn, that it has not already learned and that it does not learn by pure trial and accidental success, that is, quite by himself without profiting by what is observed. Sometimes in these experiments the performance of the act is done by the experimenter, sometimes by another animal that has mastered the act. The acts utilized are such as jumping up or down a series of steps, standing upright, clawing, pushing, pulling or pecking at a certain latch or button, using a T-shaped stick to rake in a piece of food, climbing to a perch from which

food may be reached, using a stick to push food out of a glass tube, reaching into a bottle to pull food out, etc. Nearly all animals show what, compared to the behavior of a bright child, appears to be astounding stupidity under such conditions. While there are a very few cases of learning, mainly among monkeys, chimpanzees and other primates, which may have been due to observation, usually the animal profits nothing by observing a performance even ten or fifty times. Learning by observing a performance is rare even among the most intelligent beasts. They must learn through the try-and-try-again process with little abridgment. While they may appear to be as observant as human beings, we may be certain that their observations are markedly less effective. At the most they seem to learn merely that such and such is the *place to work,* without learning perceptibly *how* to work. In the anecdotes of animal learning that most of us hear from time to time, what is alleged to be the learning of an act by observation is really learning merely a place to work.

Children and adults learn much by observing performances by others and thus abridge the trial-and-error process considerably but rarely fully. If the act observed is very simple and within our motor, emotional or mental equipment at the time, we may be able to do it. If I clap my hands—1, 2, 3 stop, 1, 2, 3 stop, etc., you observe the pattern of reactions that you can already make and you can at once duplicate them, since it is easy. But if I pat the top of my head rapidly with my left hand while rubbing my abdomen slowly with a circular motion, you may observe precisely what to do yet be unable to do it. Now, reverse the hands. Patting the head with the right hand, while rubbing the abdomen with the left, while no harder to observe, it is much harder to do. Observing the skilled

pianists is of some value to the novice but by no means a substitute for trial-and-error learning. Furthermore, a person may observe how well another controls his anger at interference, his fear of thunder, his grief at misfortune and while often helpful in some measure, such observations are not enough to enable one to do the same. Similarly, observing skilled acts in tennis, boxing or drawing hundreds of times while often helpful is not alone sufficient. Learning by observation of a performance is rather exclusively human. It is a valuable supplementation of, but by no means a complete substitute for, the trial-and-error procedure.

Summary.—In sum, however more complex human learning may be than that of animals, the fundamental features are strengthen and addition, weakening and elimination of connections during the process of trial, error, and success. In addition to native advantages in rate of neural modification and retention, the human learner is more proficient because he can and does observe more and better the results of his trials and errors; because he can and does utilize more and in better ways, ideas developed during observation; because he can and does recall these ideas in the absence of the things observed; because he can and does observe and profit by the performance of others.

The Course of Improvement in Learning Complex Functions.

Before undertaking a discussion of the means of learning most rapidly and economically, it will be advisable to observe typical human progress in several complex functions which are learned without a considerable amount of guidance or tuition. Such investigations yield a picture of many characteristics of representative human learning

rather than of the progress of learning as it might appear under ideal management and tuition. We shall take up first various features of the *curve of learning,* which gives a graphic picture of the amount, rate and limit of improvement brought about by practice.

Most of the functions learned in school or everyday

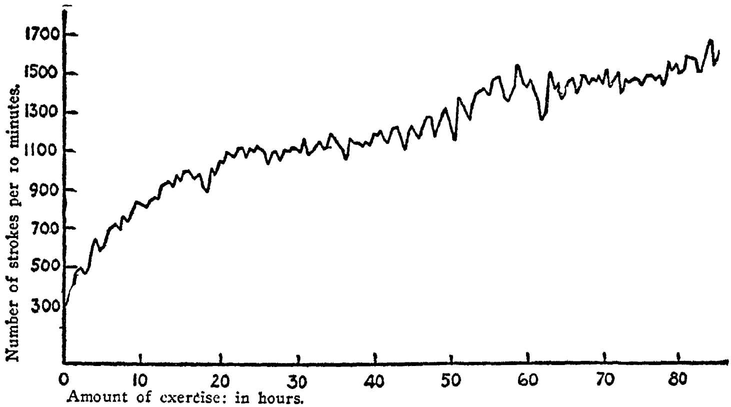


FIG. 35—IMPROVEMENT IN TYPEWRITING BY THE "TOUCH" METHOD. Between hours 25 and 45 little improvement is made This period might be called a plateau. (From Thorndike, *Educational Psychology,* Vol. II, p. 138, after Book.)

life are very complex, including many particular S-R connections. During the progress of learning, changes in the combination of connections are constantly going on. The final proficiency is not merely the performance at the beginning done more rapidly; it is a different performance. Curves of learning, consequently, portray the progress of improvement in a changing complex of connections. They do not picture the influence of exercise and effect upon a single neuron or even upon a constant group of S-R connections.

Shape of Learning Curves.—The actual curves of learning, which are available in large numbers, are of

various shapes. The forms are determined in part by the nature of the function itself and in part by the ability, methods of work, and previous training of the individual learner and the circumstances under which he works. There is no single or typical curve of improvement, but many different varieties of which a few representative samples are given in Figures 35 to 38, inclusive.

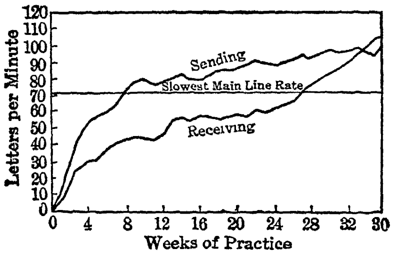


FIG. 36.—IMPROVEMENT IN TELEGRAPHY. The upper curve shows the results for transmitting messages; the lower the rate of receiving. Note, just above the word "receiving," the plateau which extends over a period of nearly ten weeks, followed by a rapid rise. The line marked "slowest main line rate" indicates the slowest rate at which commercial messages are sent. (From Starch, *Educational Psychology*, p. 142, after Bryan and Harter.)

Study of the various curves will show that a rapid initial rise is a frequent but by no means universal characteristic. The actual increase in the output rises rapidly in the earlier stages and usually more slowly at the final stages of an extended experiment on the acquisition of skill. This is not necessarily an indication that one is learning better in the early stages; usually it means only that what is learned has greater effect upon the score. When one begins to typewrite, for example, searching out each individual letter makes the number of words written per minute very small. But to memorize the positions of a dozen of the most commonly used letters, which is not a very difficult task, increases the output greatly. When one has reached a speed of thirty words per minute most of the easy tricks have been mastered, and to secure an equal increase in the score demands the learning of a

great many more difficult acts. If, on the other hand, we consider the number of new Latin words one can learn in a given unit of time, we shall probably find that it increases as practice goes on. This is due, mainly, to the fact that after one has mastered a number of roots, prefixes, rules, etc., it is an easy matter to pick up a dozen new words; the "new" words being, as a matter of fact, not wholly new but composed of one or more parts already more or less familiar. This is generally the case in acquiring information; the more history, psychology, or mathematics one already knows, the easier it is to learn a new lesson. Such differences in functions result in different kinds of learning curves.

The Physiological Limit.—In the case of such skills as typing, writing, etc., an absolute limit of improvement is theoretically possible but practically almost never achieved. The *physiological limit* is that degree of ability which a particular person cannot surpass because of absolute limits in the speed or complexity of motor or mental response. In running a hundred yards, jumping, tapping with a pencil, or other functions which depend upon sheer speed and force of muscular contraction with relatively little opportunity for developing new technique, the limit may be reached. But in complex performances such as typing, drawing, playing the piano, carpentry, or surgery it is very seldom reached. In acquiring information in any field—law, medicine, history—there is no physiological limit; there is always a possibility of learning more, although there is a limit to the speed with which the items may be acquired. But in most functions which have been steadily practiced for years, such as writing, reading, shaving, opening envelopes, tying neckties, sorting cards, memorizing or studying, we are performing with a speed and efficiency far below our maxi-

mum possibilities. Under special incentives such as keen competition, typesetters, telegraph operators, and typists in industry, as well as readers, writers, or spellers in school, frequently rise abruptly from a dead level which had held them for years.

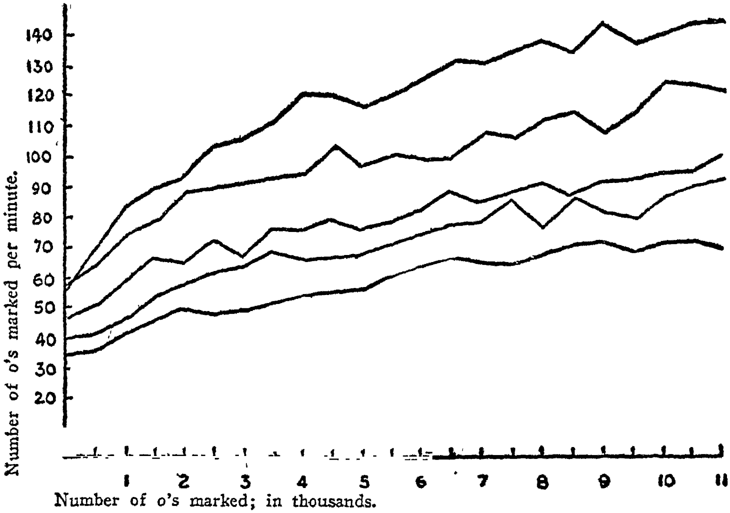


FIG. 37.—IMPROVEMENT IN CANCELLING O'S FROM ROWS OF DIGITS BY FIVE SUBJECTS.—Note that the shapes of the curves differ among individuals and that the largest improvements are made by those who show the greatest ability at the beginning. (From Thorndike, *Educational Psychology,* Vol. II, p. 124, after Wells.)

When any habit becomes fixed, it is invariably annoying to disturb it. The prime condition of improvement is that the performance at the time be broken up and reorganized in better form, *i.e.,* on a higher level. Most of us eased off in our learning of reading, writing, and many other school functions as soon as we safely could—perhaps in the fifth or sixth grade—and entrenched ourselves in a low level performance, from which we have never emerged. Few people know how rapidly they read or

write, how efficiently they memorize or solve arithmetic problems; few know when their improvement came to an end, or whether they have made any improvement in the last year or ten years. If you should now suddenly undertake to increase your speed of reading it would be found disturbing and perhaps unpleasant for a time, the inevitable result of breaking up an old organization of habits to supplant them by new. But this is the only way in which more effective habits—perfectly comfortable once habituated—are attained.

Even in learning under experimental conditions, in which the incentives to improve are great, especially when each day's work is recorded, the progress measured, rewards offered and competition provided as incentives, the tendency to ease up is quite usual. Sometimes this shows itself in a level or "plateau" in the curve, although some levels, even declines, are otherwise occasioned. Figure 41 illustrates plateaus out of which the curve of learning emerges to reach higher levels. Often under ordinary conditions of life or school, where actual improvement is less emphasized, cherished and rewarded, the plateau becomes a permanent level.

Plateaus in the Learning Curve.—Plateaus may, however, occur despite an interest in improvement and an effort to secure it. Sometimes they are due to unintentionally but unhappily hitting upon a bad habit or method which interferes with further progress until it is eliminated. In writing, a pupil may develop an unfavorable sitting position or too firm a grip of the pencil; in reading, a habit of pausing too frequently in a line, or of giving too much attention to the minute details of words; habits which may inhibit progress until they are accidentally or by means of the teacher's instructions corrected. Plateaus may be caused by eye trouble, fatigue

and other physiological conditions, despite intentions to improve. Sometimes levels in the curve, persisting for days or even months and often discouraging to the learner, are encountered when actual progress is being made. In reading, the introduction of visual analysis of words may temporarily disturb the pupil's facility. When his performance is measured by the speed and accuracy of reading, he may appear to have lost some ability; but the cause of this apparent loss may be simply that the learner is passing through a period of transition to a higher level during which no immediate improvement is secured. Progress may be real but concealed; the learner may emerge with greater ability to recognize new and long words. In typewriting such plateaus sometimes appear during the transition from letter to word units. The shift from one stage to another is seldom abrupt; a good deal of overlapping is the rule, and while the one is shading into the other, errors and periods of confusion are frequent. The danger is that these will so annoy the learner that he will drop back to the lower but more familiar level.

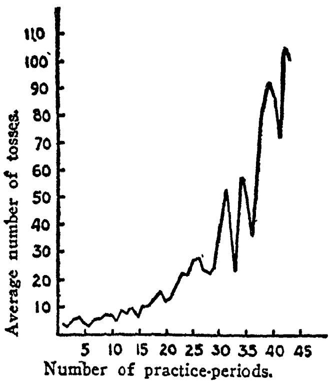


FIG. 38.—IMPROVEMENT IN TOSSING AND CATCHING BALLS. The improvement is slow at the start but becomes more rapid as the subject becomes more proficient. Compare with Figures 35 to 38. (From Thorndike, *Educational Psychology,* Vol. II, p. 120, after Swift.)

Short Time Fluctuations in the Curve of Learning.—The plateau, which is a long time level or depression in the curve of learning, lasting for weeks or months, is not

a universal characteristic of any function or any person; but short time, day-to-day ups and downs are practically universal. (See Figures 35-38.) These fluctuations are due to temporary habits, good or bad, differing bodily conditions, interests, distractions, incentives, or other temporary influences. Individuals will have not only good and bad days, but good and bad hours, or minutes, during the same day, often for reasons that are difficult to discover.

The Influence of Disuse.

Disuse is, of course, a passive state in which the mechanisms, trained during practice, are left inactive. The effects of practice gradually die out at a rate which depends upon the native retentiveness of the particular neurones for the particular individual concerned. No satisfactory information has as yet been secured concerning the precise rate at which particular connections strengthened by exercise weaken through disuse, or to what limits the effects of disuse may go. The whole matter of the change in a particular bond occasioned by disuse must be treated hypothetically by deduction from the rather crude experiments upon complexes of connections, constituting functions such as memorizing words, learning telegraphy, and the like.

In the previous chapter, we described a case of a child who learned to react to the spoken word "leaf" by thinking of the object when the word and object were presented together repeatedly. To begin with, the connection between the word "leaf" and the conscious reaction or idea of leaf was very weak. In Figure 39 this is represented as above zero but below the "limen" of recall; that is, the connection is not strong enough actually to produce the response. One simultaneous reaction to the word and the

object strengthens the connections somewhat, but not sufficiently to provide the response. Further repetitions gradually increase the strength of the connections until, perhaps, after thousands of repetitions, it reaches a limit —the physiological limit—which represents the strongest and most permanent connection possible. There are, then, various degrees of strength in a connection, from zero up to the threshold (or limen) of reaction and from that point on to a theoretical limit. One may study an item to a point where he can barely recall it, or overlearn it to various degrees. The more thoroughly it is overlearned, the more promptly, surely, and easily it can be recalled. If the reactions are now given no exercise, disuse gradually results in a weakening of the strength of the connections, which would result in a lessening of the promptness, certainty, and ease of recall and, finally, in inability to recall. But even when the connection becomes so weak as to lie below the limen, there are still differences in degrees of strength, or in other words, differences in degrees of weakness between the limen and the zero point.

Overlearning and Disuse.—From the experimental studies, which are unfortunately very few, it appears that the rate at which connections lose strength through disuse depends mainly on how strong they were at the beginning of the period—that is, on how much they were overlearned. Reactions greatly overlearned, such as our names, the A B C's, and many familiar words, or motor acts as holding a pencil, or humming "Home, Sweet Home," will probably function after thirty, forty, or more years of disuse, although they will have lost more or less of the original promptness and ease of action. Names of old friends, the appearance of the scene of a summer's vacation, a poem or song greatly overlearned,

the act of catching a baseball, and other acts representing connections less thoroughly established will remain above the threshold of reaction for many years, and thus, by various degrees, we may come down to responses that were originally exercised sufficiently to place them barely above the threshold of reaction.

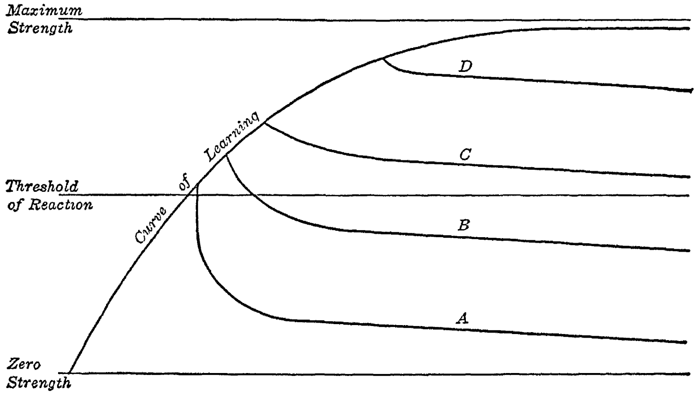


FIG. 39.—PROBABLE INFLUENCE OF DISUSE IN THE CASE OF FUNCTIONS OVERLEARNED IN VARIOUS DEGREES. Curve A shows the loss or forgetting which occurs when the function is barely learned. The initial loss is rapid and great, followed by a much slower rate of deterioration. B, C and D show probable losses in functions which are overlearned slightly, considerably and greatly, respectively. In all cases, after the rapid initial loss, the strength of the connections steadily but slowly decreases.

Curves of Forgetting.—It is upon functions barely learned that most of the experimental studies of the effects of disuse are based. A pioneer investigator in the field (Ebbinghaus) examined the permanence of his own learning of non-sense syllables after they had been barely learned—that is, learned until he had made just one correct recitation. Practice was given up, and after a period of disuse he relearned the same series. The loss in the strength of connections—or, as it is more accurately expressed in this case, "the amount of forgetting"—is

measured by the relative amount or percentage of time taken to relearn the material to the point of one recall. The loss of ability, as thus measured, is very rapid at first and then tapers off gradually. In another study (by Strong) were obtained about the same results when different materials and a different method of measuring forgetting was used. Another investigator (Radosavljevich) found that when non-sense syllables were learned more thoroughly, namely, until they could be recalled twice in succession, the effects of disuse were not so great. The first investigator found that after twenty-four hours of disuse, two-thirds of the original time was required to relearn, whereas the last investigator found that when material was overlearned slightly (two correct recitations instead of one) only one-third of the original learning time was required to relearn after twenty-four hours.

Figure 39 illustrates roughly the probable curves of disuse which may follow various stages of overlearning. These relations, however, are merely estimates based upon the few facts now available. They are intended to present roughly the general facts that the rate of loss through disuse depends upon the degree of learning and that loss goes on both above and below the threshold of response.

Loss of Motor Ability from Disuse.—Information is seldom overlearned to the extent that skill is. Writing, reading, speaking, typewriting, and swimming are complexes of large numbers of connections, some of which must be tremendously overlearned before even moderate proficiency in the function as a whole is possible. Many of the constituent connections, moreover, are really not idle during disuse, but are being exercised in other skills and thus kept strong. With complete disuse, the connections involved in motor functions do die out and, when

originally overlearned to the same degree as the bonds involved in acquiring information, the rate of deterioration is probably about the same, although it is not impossible that the latter are somewhat less stable.

Degree of Retention Conditioned by Methods of Learning.—The effects of practice, then, die out gradually at a rate which depends on the amount of overlearning, and on the native retentiveness of the particular neurones in the particular person concerned. There is no way in which one's native retentiveness may be increased so far as is now known. Whatever the degree of native retentiveness anyone may possess, the permanence of retention is determined by the way he learns, not wholly by the time spent in practice, but in a large measure by the way in which the time is spent. Learning, as was illustrated earlier in this chapter, is more than mere repetition. Economical learning and as a consequence optimum retention—since retention is a passive matter depending partly on the process of learning—depends on utilizing effective incentives, on eliminating the wrong and selecting the right reactions with dispatch, on overlearning to the right degree, neither too much or too little, for the purpose in hand, and on a number of economical devices to which succeeding chapters will be devoted.

QUESTIONS AND EXERCISES

1. Collect some instances of animal learning in which ideas or understanding seem to have been present. See if you can explain the learning in other ways. If no other explanation is apparent should you, as a scientific thinker, conclude that ideas or understanding was present? Review the relevant sections of Chapter 1 on this point.
2. Thirty years ago most of our notions of how animals learn were based on what is called the "anecdote method." What, probably, was this method and why is it not now trusted?

3. Make a list of functions acquired by man but never learned by animals. Which of these may be explained as probably due to the limitations of the animals' (a) sense organs, (b) muscular mechanisms and (c) intelligence. Enumerate some very skillful acts that animals learn during wild life or as the result of tuition as among circus animals. Explain them as due to specially well adapted sense organs or muscular mechanisms.
4. Summarize the main similarities and differences between animal and human learning
5. An experiment upon improvement in reading. For practice, attempt to speed up in all of your daily reading for 30 days. Try to bring about an increase in speed by pushing yourself beyond your ordinary rate. Give yourself a test, at about the same time each day, by getting some one to time you while you read for 10 minutes as rapidly as you can comprehend. For test material use a book of moderate and uniform difficulty. Record the number of lines read on each 10-minute test. Plot a "curve of learning."
6. Compare your progress with that of others. At the end of 30 days, see if you think you have reached your limit. How can you be sure whether you are on a plateau or at your physiological limit? Test your judgment by continuing the experiment. Was the general curve uniform or irregular? Can you account for the small variations from day to day?
7. Just what is meant by the physiological limit? In what functions have you reached your physiological limit? See if you can increase your speed of tapping or of saying the ABC's.
8. Name functions in which a slight improvement can be attained only at a great cost of time and effort. Name some in which the experiment is worth the cost; some in which it is not.
9. How may we determine the optimum development of school functions—reading, spelling, writing, typewriting, speed and accuracy of multiplication? Cite opinions or experimental evidence concerning the degree of efficiency demanded by various vocations.
10. Can you give any illustrations from your own experience in which improvement has been blocked by the formation of inappropriate habits, loss of interest, staleness, or fatigue?
11. What is meant by "overlearning"? What is overlearned when one can typewrite 60 words a minute?

12. Cite a dozen functions which the high school graduate has overlearned. In what cases has there been too much, in what too little, overlearning?
13. Suggest an effective way of relearning poetry or names in order to give special practice to those bonds which generally need relearning.
14. What does a pupil in school know about his curve of learning in various functions? What should he know? How might such curves be secured?
15. Criticise this statement: "We learn to swim in winter, and learn to skate in summer." Account for any appearance of improvement as a result of a period of no exercise.
16. Why is it that certain experiences of childhood are apparently very well remembered?
17. In what functions does it appear that loss is very great from disuse? In what ones does it appear to be less great?
18. James states that "Nothing we ever do is in strict scientific literalness wiped out." Just what is meant by this? Certainly, experiences are "forgotten," that is, cannot be recalled consciously. What has become of them and how may they function? What evidence can you cite to show that some trace of past experience may function years after it is forgotten in the sense that it cannot be consciously recalled?
19. Is there a single typical curve of forgetting for all functions?
20. If one plays tennis only 2 months per year, but plays baseball 3 months and handball 7 months, would you expect the skill in tennis to deteriorate during the 10 months as much as if baseball and handball were not played at all? Explain.
21. List and define all the new terms found in this chapter.

GENERAL REFERENCES

Good brief accounts of the characteristics of learning of man will be found in the following: F. N. Freeman, *How Children Learn,* Boston: Houghton Mifflin, 1917, Chapters 8 and 9. Daniel Starch, *Educational Psychology,* New York: Macmillan, 1919, Chapter 11. E. K. Strong, *Introductory Psychology for Teachers,* Baltimore: Warwick York, 1922, pages 29-98.

More extensive accounts will be found in: E. L. Thorndike, *Educational Psychology,* Vol. II. *The Psychology of Learning,* New

York: Teachers College, 1913; W. H. Pyle, *The Psychology of Learning,* Baltimore: Warwick and York, 1921.

The results of the first scientific studies of animal learning will be found in E. L. Thorndike, *Animal Intelligence, Experimental Studies,* New York: Macmillan, revised edition, 1911. A more recent summary of the work in this field appears in John W Watson, *Behavior: An Introduction to Comparative Psychology,* New York· Holt, 1914. Other good books are, *The Evolution of Animal Intelligence,* New York: Holt, 1911, and *Studies in Animal Behavior,* Boston: Badger, 1916, both by S. J. Holmes, and *The Mentality of the Apes,* New York: Harcourt Brace, 1925, by W. Koehler.

REFERENCES TO STUDIES UTILIZED IN THE TEXT

On maze learning: J. B. Watson, *Behavior, op. cit.,* and M. C. Gould and F. A. C. Perrin, "A Comparison of the Factors Involved in the Maze Learning of Human Adults and Children," *Journal Experimental Psychology,* 1916, pp. 122-154.

On learning non-sense syllables: A. I. Gates, *Recitation as a Factor in Memorizing,* New York: Columbia University, Archives of Psychology, 1917, pp. 65-104.

On learning typewriting: W. F. Book, *Learning to Typewrite,* New York: Gregg Pub. Co., 1925.

On the rate of forgetting: H. Ebbinghaus, *Memory,* translation by H. A. Ruger. New York: Teachers College Bureau of Publ., 1913; E. K. Strong, "The Effect of Time Interval upon Recognition Memory," *Psychological Review,* 1913. Other studies are summarized in Thorndike, *loc. cit.*

CHAPTER XII

ECONOMICAL METHODS OF LEARNING.

Animals are unable to profit materially by the observation of the performance which they are striving to learn, by the use of models or by guidance mediated through ideas otherwise expressed. They learn almost exclusively by unrestricted trial and accidental success. The human learner, on the other hand, may profit considerably by insight achieved by observation and by instruction concerning methods of procedure. Both human and animal learners may be helped, however, by means of properly managed motivation, rewards and punishment, by the optimum arrangement of practice periods, their length and distribution, and by other types of mechanical supervision. To these methods of abridging the process of learning, which is laborious enough at best, the present chapter will be devoted.

The principles of economy will be grouped with reference to two types, or really two phases of learning:

1. The acquisition of motor reactions or skills.
2. The acquisition of facts and information, usually termed memorizing.

This division is made not because the principles differ in the two instances—they are essentially the same—but merely for convenience in discussion. Were the principles of economy fundamentally different for the several phases of learning, practice in most functions would afford most puzzling problems. For example, in learning

to read one must take care of the formation of proper motor reactions, the highly complex habits of eye control and the management of articulation, audible or silent, and of the acquisition of ideas, that is, of comprehension or thought getting. If the rules for guidance were essentially different for these phases—and in almost every instance of human learning both are present—marked economy could scarcely be achieved. Fortunately, the main principles are everywhere the same; although, unfortunately, in many instances they are not altogether clear.

Principles of Economy in the Acquisition of Motor Skills.

Evidence That Guidance Is Desirable.—We need only to point to the "hunt-and-hit" methods of typewriting, the "pulls" and "slices" in golf, the cramped grips in writing, the "dog-fashion" strokes in swimming, to convince most people of the inadequacies of unguided learning. By teaching and guiding the learner to acquire the "touch method" of typing, the proper golf swing, the positions and functions of the fingers in writing, or the "crawl" stroke in swimming, much higher proficiency is achieved. The learner left to himself usually adopts the first method he stumbles upon, a method that is rarely good. The effective methods often are more difficult in the early stages, immediate returns are often meagre, and, in general, the unguided learner seeks immediate progress; he follows the line of least resistance. Not only, then, is it the business of the teacher to know *what* to learn but also *how* to learn.

Know the Character of Effective Performance.—The first requirement of an instructor, or of a person managing his own learning, is knowledge of the character of

the good performance. To determine this is often difficult and may be done only by extensive research. There are a number of brilliant examples of such achievements. An interesting one was the analysis of good and poor bricklaying. By the device of photographing the movements of small electric lights attached to the bodies and hands of various workers, an investigator (Gilbreth) was able to detect wasteful operations both among expert bricklayers and those learning the trade. He was able finally, by reducing the number of movements and substituting quick and easy ones for slow and hard ones, to increase the achievement of an average laborer from 120 to 350 bricks per hour. By the use of the same device, or of "slow" motion pictures, similar improvements in technique have been and still may be accomplished in industrial skills. In school functions such as writing, drawing and eye movements in reading, similar studies have been made. In tennis, baseball, pole vaulting, typewriting, playing musical instruments, indeed in many types of motor skill, such analysis made by skillful hands will make possible substantial improvements in teaching and performing.

The Observation of Performances and Models.—Having ascertained the detailed operations that will yield the beset results, how are they to be taught? The first problem is that of taking advantage of human capacity to profit by observation of a performance or a model. Choice here is determined entirely by the clearness with which the performance or the model illustrates what is to be done. Despite the great number of functions in which learning is more or less guided by our observations of others in action, most of the motor activities in common skills are exceedingly difficult to perceive. Inasmuch as he does not always know just what to look for or where

or how to look, the learner often profits little by observing an expert typist, tennis player, golfer or singer. Especially the child finds difficulty in seeing how the teacher writes, dances or ties a knot. To referee—that is, to observe skillfully—a boxing contest or wrestling match; to umpire a baseball game, or judge a diving or dancing contest is a fine art requiring years of experience. Were finer movements not difficult to perceive, the sleight-of-hand performer would have failed long ago. Learning by observation is difficult. It is brought about in no mysterious, instinctive or intuitive way; it is effective only in so far as the learner does perceive what the desirable reactions are and may then be able to guide his own trial-and-error learning accordingly.

The skillful instructor should be a good actor, able to single out a particular movement and perform it alone and able to slow up a movement to afford more deliberate observation. The use of diagrams, mechanical dummies and slow-motion pictures often make possible the display of a movement more clearly than the observation of the original. There is no intrinsic advantage, because of our original nature, in any type of model. It does not matter in the least whether the model is a living movement, a picture of a movement, a lifeless copy, or what. The one criterion is the faithfulness and clearness with which it displays the ends sought. Other things being equal, that model is best which makes the desired reactions most intelligible and provides the most effective means of distinguishing errors and successes.

Putting the Learner Through the Reaction.—In addition to the use of observation of movements and models, another form of tuition that has from time to time attained popularity consists in putting the learner mechanically through the reaction or at least in providing some

mechanical guide which enables him easily to put himself through. In writing, for example, this may be done by guiding the child's hand through the letter movements or by providing letters grooved in wood or metal through which the child pushes his pencil, or by allowing him to follow with his finger the sandpaper outlines of letters, or to trace on tissue paper the forms of letters visible through it. There are two ways in which putting the learner through the reaction or mechanically guiding his progress might, conceivably, be of value:

1. By providing a clear idea of what is to be done.
2. By giving the mechanisms involved artificial exercise in the way they should function.

At first thought, this device would appear to provide a simple way of eliminating the errors from what would otherwise be trial-and-error learning.

What seemed, theoretically, to be the best of these devices, the tracing of letters on tissue paper placed over letter forms that were clearly visible through the paper, has been tested experimentally (Gates and Taylor). Two squads of children with about equal intelligence and motor ability but without previous experience in writing were selected. One squad practiced daily the tracing as described, the other practiced actual writing, using a model placed above the writing page. After about a month of daily practice on ten different letters, both groups were tested for several days in real writing, using only the model as guide. Some were almost completely baffled. They were familiar with the shapes of the letters, knew at what points to start and in what direction to proceed, but for them writing a letter on a blank page was a very different performance from tracing a form which showed itself through a thin paper. Some of them simply could not produce a legible letter; their consternation and

chagrin was pathetic. Adults may get a taste of the confusion and annoyance which these children experienced by attempting mirror-drawing, that is, attempting to draw, or even to trace the outline of a star when the hand and paper are seen only as reflected from a mirror placed upright beyond the paper. A person may know what product he wishes to produce, but most of his efforts lead astray.

Direct practice in writing, in this experiment, was more effective than tracing. It would surely be also more effective than being put through a reaction more mechanically. Knowledge of what to do, where to start, etc., were obtained as well or better by direct writing. The muscular and kinesthetic sensations from the movements obtained by being put through are too vague and confused to be useful. The most significant factor, however, is this: the exercise of being put through or of tracing is not the exercise of actually writing. We are led again to an important generalization, one previously noted; *one learns precisely the reactions that are exercised.* In being put through a writing movement, the subject learns, not to write, but to be put through writing-like movements; by tracing in a groove he learns to trace in a groove, by tracing letters seen through tissue paper he learns to do precisely that. The novice who practices swimming while supported by an inflated tube, after all usually fails to learn to swim by this means alone, while learning a number of things, such as balancing on a support, which are irrelevant. There is some transfer from such artificially controlled practice—the children as a group had learned some items that facilitated learning to write—but practice of this character is usually less productive than the direct type. Except in so far as putting a learner through a reaction serves effectively to

show him what the desired reaction is, such practice is of relatively little value.

The Use of Formal Exercises.—A frequently used device in learning consists in the specific practice of some element of the whole function. For example, in swimming the learner may grasp the edge of the tank and practice singly some part or the whole of the leg movement; in singing he may repeatedly do certain limited exercises; in athletics "formal" setting-up exercises are extensively used; in writing, many methods have elaborate systems of particular exercises such as repeated making up and down marks, ovals and reverse ovals, swings, loops, and so on. The theoretical basis of such formal exercises is the notion that to master the whole one must master the parts, that if one learns to do singly all of the elemental acts in a complex function, putting the single acts together will be relatively easy.

This theory is quite erroneous. Learning to do the parts singly is by no means learning to do the whole. The greatest difficulties are often encountered in putting together the elements. Moreover, the elements are often already sufficiently developed without the preliminary practice; if not, they are usually more economically perfected in practicing the whole. Those which do not develop sufficiently while practicing the whole may well be handled singly later, but not until it becomes necessary. We should not begin with elaborate formal exercise of the elements or make them a large part of the course of training but utilize them as strictly preventive measures where difficulty is beginning to appear or as remedial measures where a particular defect or deficiency is apparent.

The Discovery of Errors.—As the term "trial and error" suggests, the appearance of inappropriate reactions

at all stages is characteristic of motor learning. Devices which help the identification and elimination of errors, unless they introduce other inappropriate reactions equally bad, are much to be desired. In the subtle elements of writing, speech, tennis and other skills, the instructor has the double duty of being constantly on the alert for errors, usual and unusual, and of instructing the learner in the ways of detecting and eliminating his own inappropriate acts. Prevention is, of course, better than cure. Prevention may be secured to a considerable extent by giving very diligent attention to the initial stages of learning. In studies of children's first lessons in reading, it was found (by Meek) that inappropriate methods of attack, hit upon in the first endeavor to learn, may be so persistent as to make later progress difficult and the work distasteful. Such difficulties may mark the beginning of "disabilities" in reading. The cases of "disability"—children who are persistently very backward and experience extreme difficulty in learning—may be brought back to efficiency only by ingenious or extreme measures later. The procedure for treating such cases comprises the following essential steps:

1. Diagnosis of the particular defects or deficiency responsible for the trouble. This is often an intricate task, demanding considerable insight into the particular skill as well as understanding of human nature.
2. Making clear to the learner the sources of the trouble.
3. By encouragement or other devices arousing a strong desire to overcome the difficulties and to achieve normal ability.
4. Providing remedial exercises designed specifically to supplant the inappropriate reactions by effective ones.

It is very important to detect and make annoying the appearance of the old undesirable reactions and to disclose and make satisfying the new substitutes. Above almost everything else, knowledge that progress in the right direction is being made is a stimulant to further successes. In this work, as indeed all along, the instructor or coach should constantly be on the alert for the recurrence of old or the appearance of new errors. They should be detected before they become fixed, and the proper response suggested. When an error is once eliminated, it should not be mentioned again. Emphasis should, then, in general be placed on the correct reaction; but the incorrect response should never be ignored.

The learner himself should be trained to detect his errors and successes. It is quite clear in observations even of adults in laboratory studies, that most students are unnecessarily poor learners, unnecessarily blind to their errors and successes. Partly these deficiencies are due to the scant attention usually given to methods of learning. With a little attention to technique, most of us can become more systematic and more alert to our own reactions, and thus increase appreciably our ability to learn in each line. In learning to read, sing, and the like, the recording of the voice, which is later critically studied, usually aids greatly the process of learning. In other types of learning, photographic and other records may be fruitfully used.

The Directing of Attention.—In connection with these suggestions concerning the value of directing attention to and discovering errors, an erroneous theory of the value of concentration on the sensations which arise from the activities of the muscles, tendons, and joints merits a word. This theory assumes that if one is attending to the sensations from the organs of response when a good

reaction happens to be made, he may later reinstate the response by calling to mind the complex of sensations. As one writer puts it: "A movement idea is the revival, through central excitation, of the sensations, visual, tactile, kinesthetic originally produced by the performance of the movement itself. And when such an idea is attended to, when, in popular language, we think hard enough of how the movement would 'feel' and look if it were performed, then, so close is the connection between sensory and motor processes, the movement is instituted afresh."

Ask a golfer what ideas he tries to activate before making a stroke. He will not say that he tries to recall the hundreds of sensations from the body that he previously felt during the process of making a good stroke. He could not possibly do so if he tried. His ideas may be thoughts of cautions such as: "Now, don't get excited," or "Take your time," or "Keep your eye on the ball." As for the expert, the less he thinks about how he feels or how it felt to make a good stroke, the better. He simply makes the preparatory reactions—adjusts his feet, bends his knee, places the club, and goes through with the stroke with no thoughts of the movements whatsoever.

The whole notion that a learner profits by attending to the sensations from the members employed in a complex act is erroneous. Attention should be directed to:

1. The features which assist in securing the correct preliminary orientation.
2. Features which help in detecting errors or successes in the act.
3. The general outcome of the act.

If one is trying to throw a baseball over the plate, he must first observe and thereby locate the plate. When

the movement is under way it is wise to look at the plate, although at times—in practice—it pays to give attention to some part of the process which is troublesome. Thus, the pitcher may be stepping out too far; an error which he must detect and remedy. He should know both when his moves are incorrectly and when they are properly performed. As soon as he gets the act going right it is better to think about it no longer. The other feature which deserves attention is the outcome of the total act: the pitcher should try to observe accurately just where the ball went; and try to account both for successes and errors.

The same principles hold for other forms of motor activities. In writing, the learner must first get the correct position, and second, keep on the lookout for good and bad movements by watching the product, trying at the same time to detect the causes of errors and successes. As he masters the act, the conscious reactions gradually drop out because they are unnecessary. Nowhere does the attempt to get an idea of how a movement feels contribute anything useful to the production of the movement.

Summary.—The positive suggestions for economy in motor learning are the following:

1. Make a real study of the characteristics of the function that is to be learned. For this purpose may be utilized
   (a) verbal descriptions where they exist;
   (b) direct observation of good performers or, usually better,
   (c) pictures—especially slow motion pictures —graphs, or other mechanical aids.
2. Make a real study of your own reactions as you learn. Develop ability to compare your own detailed acts or products with those of others and

thereby detect and remove errors, select and practice successes.

3. Do not depend upon formal exercises of parts of a function except where the part offers unusual difficulty; on artificial exercise obtained by being put through a reaction except as a devise for assisting observation of the form of the reaction; on the muscular and kinesthetic sensations. When in doubt as to the value of some unusual device, recall the principle: *one learns exactly the reactions he practices.*

Economical Methods of Acquiring Information or Memorizing.

Informational Learning as Reacting.—In the acquisition of information, great difficulty has come from the notion, often accepted in practice if not in thought, that a fact is a fact, and it will function without regard to *the way in which* it is acquired. It is often assumed that if multiplication tables, vocabularies, or names and dates in history are thoroughly learned, it matters little how they are learned. This is completely to disregard the fact that what we learn in these cases is not subject matter but, as elsewhere, particular reactions. We have added to our equipment certain responses which can function only in certain ways—ways determined by the manner of learning.

The first principle, already mentioned under motor learning but especially needing emphasis here, is this: we learn the reactions that we make. An investigator (Myers) once asked a large number of students whether the four on their watches was a IV or a IIII. Of 200 students whose watches carried a IIII, 179 declared it was IV. In spite of the fact that they had looked at their

watch faces hundreds of times, very few had made the specific kind of reaction to the IIII which would enable them to recall it as such. Similarly 192 reported that six o'clock was indicated by VI, when as a matter of fact there was no numeral at all at that hour. In another investigation, the experimenter told classes of college students that he wanted to test their ability to spell a list of words. When the six words had been written and the papers collected, the students were asked to write again the six words in the order given. Of 236 students, only five per cent recalled all of the words in the proper order; twenty-five per cent could recall the words but not the correct order, and five per cent could remember only half of the words and then were uncertain of the order. The explanation is that, having heard a word, to write its spelling is one kind of reaction, while to memorize a list of words in their order demands a very different kind of reaction.

In another case, the facts are illustrated more clearly. A student in the course of some statistical work found it necessary to use the squares of numbers from 13 to 30. Using a table which gave these numbers and their squares, the reaction—think of the number, find it on the page, look at the square, write it down—was made several hundreds of times for each number in the range; but afterwards upon test it was found that only five squares (those of 13, 15, 20, 25, and 30) could be instantly recalled. If a different reaction—roughly, think of the number, then think of its square—had been exercised specifically, all the squares could have been memorized in a short time. In the first case, the ability to find numbers and their squares had doubtless improved greatly by use; but the reactions required for recall had not been specifically exercised and consequently were not acquired.

Consider the learning of a vocabulary which is given in the book as follows:

1. *Der Mann*—the man,
2. *Der Knabe*—the boy,
3. *Der Hund*—the dog,
4. *Das Haus*—the house.

Suppose that the child learns the vocabulary by reading the pairs, one after another, in the order given. What connections are formed? Bonds between the pairs and their position in the series are made, and are especially strong in the case of the beginning and end of the list. Thus, *Der Mann* is connected with its firstness, *Der Knabe* with secondness, etc. Bonds between the first pair and the second pair, the second and third, etc.—that is, serial connections, like those acquired in learning a series of non-sense syllables—are also formed. Strong connections between the end term of one pair and the beginning of the next ("man"—*Der Knabe,* and "boy"—*Der Hund*) and between the various end terms ("man—boy—dog"—etc.) are also established. Learned in a list a great number of such connections are made, and it is upon these that the reaction may largely depend. Now, suppose you ask the boy to give the equivalent of "house"; or suppose *Der Hund* is written alone on the board. He may fail to make the correct responses in both cases although he could say the whole list as he learned it. It is something like asking an adult to give immediately the letter which precedes "q" or "o"; unless he has previously practiced just such reactions, he must get the answer in some round-about way.

One must learn precisely the reaction that will be needed for practical purposes. Usually, we study the German-English vocabulary so that later, on seeing the

German word in isolation or in various contexts we can react with the thought of its English equivalent. A good method of learning, then, would be to take small cards and to write on one side the German word, on the other the English. Shuffle several such cards in order to avoid forming the serial, position, and other irrelevant bonds. Look at the German word and try to recall the English equivalent. This demands the reaction that one will later be called upon to make.

Reading vs. Recitation.—In one investigation two general methods of reacting were tested in the course of memorizing materials. One method consisted of reading and rereading a list of 16 non-sense syllables (or a group of five short biographies totalling about 170 words) without looking up from the paper. Another method consisted in beginning, early or late, to recite—that is, to attempt to recall when not looking at the material—prompting one's self speedily by glancing at the paper when unable to proceed. The latter kind of reaction is just the kind that will be demanded later. The question is, does exercising as soon as possible the reaction that will eventually be demanded result in more economical learning and retention than the method of reading and rereading? The "recitation" method turned out to be quite superior, as is shown by the accompanying table. A study of the table will disclose several facts: (1) The greater the amount of time devoted to recitation, the greater the percentage of the lesson recalled. Of course, some time must be spent at the start in reading the material. After a few readings the process becomes partly recitation; that is, one skims over the items that are familiar, seeing a bit here and there and filling in the gaps by recall. This is true of the ordinary reading of most adults. This explains (2) the fact that one does better,

relatively, in learning sense material by reading and rereading than in learning non-sense words which, to begin with, contain fewer meaningful associations which make recall during ordinary reading possible. (3) The recitation method results in the learning of a different group

RECITATION VERSUS REREADING (FROM GATES)

Material Studied:	16 *Non-sense Syllables,*		5 *Biographies = Total of 170 Words*	
	PER CENT REMEMBERED		PER CENT REMEMBERED	
	Immediately	*After 4 Hours*	*Immediately*	*After 4 Hours*
All time devoted to reading	35	15	35	16
1/5 of time devoted to recitation	50	26	37	19
2/5 of time devoted to recitation	54	28	41	25
3/5 of time devoted to recitation	57	37	42	26
4/5 of time devoted to recitation	74	48	42	26

of bonds, the kind that makes for more permanent retention, as indicated by the fact that the greatest superiority is shown in the columns of the table which give the percentages remembered after four hours.

As pointed out previously, a fact may be learned in several different ways. The best way is to learn it in exactly the form that will be used later. This is precisely what the student does when he learns by recitation. He gradually forms and practices the reactions just as they must be exercised in recall at a later period. Another advantage of the recitation method is the fact that during learning one discovers just what parts are especially difficult or easy, and distributes his energy accord-

ingly. He finds what kinds of associative aids work and what kinds do not. Finally, the learner is aware of his progress during active attempts at recitation. In the rereading method, some were uncertain as to whether they were mastering the lesson or not; the learning becoming very irksome on that account. During recitation the learner is stimulated and encouraged by the awareness of making progress; and clear evidence of success is a great motive in learning.

The first guiding principle, then, is to consider the situation which life will present and so arrange the circumstances of learning that the learner will be practiced in making those reactions which will be demanded. Do not expect the proper response to appear as the result of incidental training.

The Avenue of Presentation.—Similar to the problem of the use of the model in motor learning, is the question of the relative values of different sensory avenues of presentation, in the case of informational learning. Are we by original nature so constituted that we acquire most readily through the visual, auditory, tactile or some other sensory avenue? So far as we know, the primary and higher neural connections of the brain aroused through one sense organ are just as modifiable and retentive as are the centers stimulated by others. Other things being equal, we learn quite as readily through one sense as another with the exception, of course, of individuals whose receiving, connecting, or central mechanisms are defective. Other conditions, consequently, determine which avenue of presentation is to be preferred. Very young children learn new words better, for example, when they are presented to the ear than when presented to the eye, for the reason that their early word experience is auditory and not visual. If they have attended school,

by the average age of eight or thereabouts children memorize better material presented visually. This is mainly because during study by reading the child can regulate the speed of reacting to the words to suit his capacity; he can attempt recall when and where he pleases; he can stop and repeat the especially difficult items, and disregard those already mastered. The differences depend on experience and methods rather than on intrinsic differences in the neural connections involved.

The relative values of moving pictures, graphs, diagrams, mechanical instruments, verbal explanations, and clay models are similarly determined by past experience and mechanical advantages. The main questions are: which method makes most clear the thing to be learned and which does it most interestingly and most economically of time, space, and money. Original nature is not so organized that we learn pictures better than words, or graphs better than models.

The Form of the Reaction.—It was stated that in acquiring information, one should practice the reaction in the way it is to be used in life, since what is learned is not an entity which we call a fact, but a particular reaction. In this connection, the question has been raised as to whether we may not be so organized by original nature that reactions made by some mechanisms may not be more readily acquired and more permanently retained than others. To illustrate: one may practice the spelling of a word mainly by articulating it, by writing, typewriting, tracing in the air with an arm movement, by moving the eyes or—eliminating these external expressions—by imagining its visual appearance, or by "hearing in the mind's ear" the sound of the letters. Which is the best way? So far as the evidence now available goes, the neural connections concerned in one type of reaction

appear to be as modifiable as those concerned in others. We may, to be sure, form habits of learning our spelling in one way or another, of learning facts from a lesson, or acquiring names, dates, and telephone numbers by visualizing, saying them to ourselves, saying them aloud, or writing them on paper and find that we are less efficient if not permitted to learn in that way. The reason in all probability is that such is our habit, associated with it are our particular techniques of learning. Any new method is likely to prove troublesome for a time. Consequently, we may still hold to the dictum: Learn the act in the way it is to function in actual life. For most of us, learning to spell by means of actual writing, therefore, would be preferred although oral spelling might be acquired quite as easily. If we are learning a poem to recite, it would be better to recite it while learning; if learning it merely to recall in thought, then reciting inaudibly is quite as good.

Formal Exercises and the Use of "Crutches."—Since we learn those reactions that are exercised we should be skeptical, in informational as in motor learning, of preliminary and formal exercises and of "crutches" or extra material introduced to facilitate one or more steps in the process. Many of the commercial memory training courses consist mainly of both of these types of devices. Under formal exercises they include everything from deep breathing and dumbbell exercises to the learning of series of names, dates, letters, facts, on the assumption that the "power of memory" is thereby trained as a whole. The fact is that the ability to memorize any kind of material must be improved through systematic practice on that kind of material. If our purpose is to improve our ability to memorize facts in chemistry, the early morning breathing and dumbbell exercises will prob-

ably be nearly as useful as exercises in learning combinations of digits. Neither will assist much.

The term "crutch" originated in school circles and refers to the temporary use of a device to assist the pupil more rapidly to master some difficult task or topic. Adding or subtracting, at first, by counting on the fingers, writing the number to be "carried" in long addition, at first, to avoid forgetting it, writing the sign + or — or × to guide the child in computing are samples of crutches used in arithmetic. These practices are quite similar to the use of inflated tubes in learning to swim, or tracing grooves in teaching writing. While they may often provide temporary aid, they often produce greater difficulties than they relieve. The objections to them is that they represent the formation of habits that later must be broken. It is sometimes more difficult to break the habits of adding by counting, once it is learned, than to have learned really to add in the first place. Certain crutches may, however, on occasions be useful and they may be employed safely to smooth a difficulty, provided they are supplanted by the proper procedures before they become habituated. In general, such devices are to be considered a last resort and then to be used with caution.

The principle of "crutches" is essentially the same as the principle inherent in various memory "aids" or mnemonic systems of which a simple form is the familiar rhyme "Thirty Days has September," etc. Like other crutches, mnemonic structures may occasionally be useful, especially where the facts, like the number of days in the several months, are difficult to learn because they are readily confused but, like other crutches, these devices are of limited utility. The most complex ones are rarely useful. The most competent learners, those professionally engaged in acquiring information, such as historians or

mathematicians, rarely use such devices. They find that, in the main, they merely add so much more to be learned in addition to the facts.

The Discovery of Errors.—Tests of school pupils and adults in language usage, spelling, arithmetic, for verse or prose previously learned, or for facts in any field usually disclose an abundance of errors. In tests of ordinary arithmetical operations practiced during a year, school children make on the average nearly two errors in every ten problems attempted. College students tested at the completion of a lecture in psychology for facts presented during the hour (by Jones) made, on the average, from 30 to 40 per cent incorrect statements. The recall of facts contained in a chapter read once carefully will be as erroneous. Such inadequacies of memory after a single repetition are to be expected, of course, but a difficulty lies in the fact that learners too frequently fail to realize which items are erroneous and proceed to practice them in further study or recall. Thus, like errors in speech and spelling, incorrect information becomes firmly established and difficult to dislodge. What one does thereafter is to practice errors.

Just as in motor learning, devices should be utilized to forestall such errors and to eliminate them when they have matured. In some subjects such as language usage and spelling, elaborate studies have been made of the types and causes of frequent errors so that the teacher may be able to anticipate those which are most likely to appear and at once instigate preventative or remedial measures. Similar studies in other fields are desirable.

Inhibitions in Recall.—Everyone has had the experience of misspelling a word, miscalling a name or writing a wrong fact during an examination, when the item itself was really well known. These errors we call "slips" or

"lapses" but there is always a definite explanation for them whether we may readily discover it or not. They occur in the motor field, too, as when we "muff" an easy ball, drop a cup or make a mis-step on the stairs. They are due to a preceding or simultaneous activity of a sort that predisposes or adjusts the neural mechanism to react in a different way; some stimulus or attitude, usually subordinate, has become prepotent. Thus if I am writing the sentence "This is the way to write the word," and begin the "w" in "way" just as I think of "word," I may write "word" instead of "way." The thought of "word," at the moment of writing "way" usually remains subordinate, but at times it gets the better of the other impulses, especially if it is a word more frequently written. In writing this sentence, a frequent error consists in the substituting of "write" for "word." This error is due to the perseveration of the effects of the recent writing of "write."

These misleading tendencies appear more clearly on those occasions when a person is blocked in attempting to recall a familiar item, a name, telephone number or a poem. In such cases, to quote William James, "The state of our consciousness is peculiar. There is a gap therein; but no mere gap. It is a gap that is intensely active. A sort of wrath of the name is in it, beckoning us in a given direction, making us at moments tingle with the sense of our closeness, and then letting us sink back without the longed-for term. If wrong names are proposed to us, this singularly definite gap acts immediately so as to negate them. They do not fit into its mould. . . . The rhythm of a lost word may be there without a sound to clothe it; or the evanescent sense of something which is the initial vowel or consonant may mock us fitfully, without growing more distinct. Every one must

know the tantalizing effect of the blank rhythm of some forgotten verse, restlessly dancing in one's mind, striving to be filled out with words." What may one do in cases like this to facilitate recall?

The cause of such failure of recall is often the same as the cause of wrong recall, indeed, in most cases we do recall things that are recognized as erroneous. The cause is the prepotency of some inappropriate response and the relative weakness of the right one. In any case the difficulty is due to an interference of an inappropriate with the usual associative connection; some preceding or simultaneous tendency of thought or a sudden stimulus such as fear, excitement, stage-fright, loss of confidence may introduce interfering elements. The best method of procedure in such cases is first to search for clues while trying to regain confidence. Instead of allowing one's self to become confused, eliminate the fear before it gets started by "substitute activity"—by plunging into an active search for clues. If it is a forgotten name, look the person over, recall his business, his friends, where you met him, etc. If it is a fact not forthcoming during an examination, confidently review related matter, recall when and where you have previously used it. This procedure utilizes the advantages of facilitating stimuli; perhaps ever so slight an additional clue will cause the item suddenly to appear. If these maneuvers fail, the best policy is to dismiss the matter abruptly and turn to other things, go on with the remainder of examination. The interfering factors are usually temporary mental activities or tendencies which subside more or less promptly. If the fact cannot be recalled during a vigorous second trial following a rest, allow another period of inactivity. If the fact is not really forgotten—which it often is, of course—sooner or later the interferences

will have been swept away, leaving the appropriate associations unmolested.

In motor performance the difficulty analogous to erroneous recall sometimes occurs in the form of loss of control. In typewriting or tennis, one may "go to pieces" in some degree, constantly making errors of one or more types. The explanation of these errors is the same as that for erroneous or blocked recall: some interference with the neural operations. The remedy is also the same: try hard, and above all, try confidently to regain control; don't allow yourself to become discouraged or angry. If mastery cannot be regained in this way, it is better to drop the task for a time since to continue would be to practice errors.

Summary.—Most of the suggestions for effective informational learning or memorizing are contained in the following summary:

(1) Learning is an active process. We learn those reactions that we practice. Hence the attack should be vigorous and the reaction should be actually the one later to be desired. We should practice actual recall of facts to be mastered.

(2) Since facts are learned through one sensory avenue as well as another, utilize the form of presentation which is mechanically most convenient.

(3) Since the central neurones concerned with one form of imagery or motor mechanism are natively no more modifiable than another, practice—in spelling, memorizing poetry, etc.—that form of reaction which will be later demanded.

(4) Use formal exercises, crutches and other mnemonic devises sparingly and never unless some special reason for them exists. Avoid learning irrelevant materials; avoid forming habits that must later be broken unless the temporary return is obvious and great.

(5) Diligently test recall for errors. Try to detect

mistakes before they are "stamped in"; avoid practicing erroneous reactions.

(6) When recall is blocked, try to adopt an active and confident attitude. Search for associated clues. These devises failing, drop the subject for a time before trying again.

Economy Resulting from Management of the Mechanical Features of Practice and Study.

In this section such questions as the optimum length of a study period, the optimum interval between periods, the distribution of reviews, and related problems will be considered. With as many different subjects as there are, and with as many variations of the length of assignments, study periods, and intervals as are possible, it is apparent that an enormous number of investigations must be conducted before all of the facts are known. While the number of studies is large, crucial evidence is lacking in many instances; and in some subjects no investigations have been made. Guidance, however, had better rest upon the implication of such experimental results as are available than upon mere opinion. The statements in the following sections are offered subject to revision in the light of results of future research rather than as final principles.

The Length of Practice Periods.—How long should a learner continuously study geography, spelling, or arithmetic or continuously practice writing, typewriting, or sewing? The results of a large number of investigations are not altogether in harmony, but they favor periods of thirty minutes or less as compared to longer periods.

In one investigation of learning in "substitution"—a rather difficult function in which the letters of words are translated into other symbols by the use of a code—a

group of subjects practiced for sixteen days, using periods of the same length, and then were divided into four groups, one practicing 15 minutes a day, another 30, another 45, and another 60. The improvement in speed in the second practice period was then compared with the increase in the first period when all were practicing in periods of equal length. This is shown in the accompanying table:

THE RELATIVE IMPROVEMENTS IN SPEED OF SUBSTITUTION WHEN THE SAME AMOUNT OF PRACTICE TIME IS DIVIDED INTO PERIODS OF DIFFERENT LENGTHS

(From Pyle)

Group	*Length of Period*	*Relative Improvement*
A	15 minutes	22.3 per cent
B	30 "	36 1 per cent
C	45 "	25 0 per cent
D	60 "	14.8 per cent

The thirty-minute practice period yields greater returns per unit of time than longer or shorter lessons. The sixty-minute period is especially unproductive.

Other investigations of memorizing, archery, typewriting, and arithmetic have shown in the main, that continuous practice longer than thirty minutes is relatively unproductive, as are very short periods of ten minutes or less. The facts vary somewhat with the functions, but, roughly, periods from twelve to thirty minutes are most desirable for adults.

For children, the optimum practice period is shorter, depending on the age of the child as well as the function. In practice of difficult motor acts, such as writing, or memorizing as in spelling, a five to ten minute period without cessation is long enough for children of six or seven. The usual procedure is to allow young children

a great deal of freedom to rest or change, with rarely more than twenty minutes given consecutively to the same general topic, *i.e.*, reading or drawing. The length of lessons is gradually increased as the pupils become older.

The Distribution of Practice.—If a learner has at his disposal seven hours a week for practice in typewriting, playing the piano, singing, etc., how may the time be most fruitfully distributed? Should he work continuously on one day for seven hours, or in half-hour periods—which, as we just found, are optimum—with intervals of a half hour, an hour, six hours or twenty-four? Experiments have not yielded entirely conclusive results, and but few functions have been tested at all. There has been a rather consistent indication, however, that by breaking up the available time into periods of thirty minutes, or somewhat less, with intervals varying from thirty minutes to twenty-four hours between, the best returns are secured. Thus it would probably be preferable to make use of the seven weekly hours by practicing twice a day for thirty-minute periods; or, if but three and a half hours were available, half-hour daily periods would be advisable. That is, one should make the practice periods no longer than thirty minutes and distribute them at fairly uniform intervals, of not more than twenty-four hours. If only two hours per week are available, it would be desirable to divide the time into daily lessons of seventeen minutes each. When this scheme of distribution reduces the length of the lesson to twelve minutes or less, it would probably be better to increase the intervals to forty-eight hours rather than make the practice period too brief.

The problem is slightly different when the task is to learn a speech, a short vocabulary, a particular musical selection, or a multiplication table. Should one learn

such short lessons at one sitting, or at several sittings with intervals between? But little experimental work has been directed specifically to this problem. In one study (by Pieron), a series of items to be memorized was read

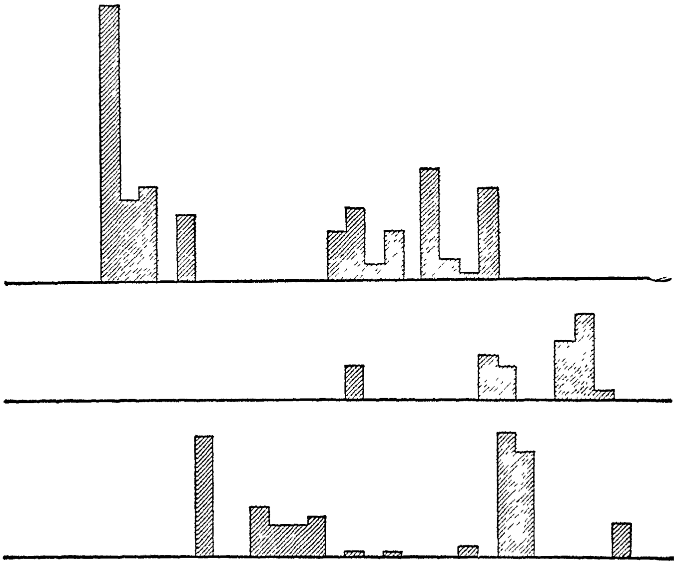


FIG. 40.—THESE THREE FIGURES SHOW THE DISTRIBUTION OF PRACTICE IN REMOVING NEGATIVE PARENTHESIS DURING A YEAR IN THREE DIFFERENT COURSES IN ALGEBRA. The width of each single rectangle represents ten successive pages in each book, or roughly, a week of time. The practice as shown by the top figure is too irregular; the long gap comes too early. The second figure would be better if reversed. The third is haphazard. See Fig. 41 for a better distribution (From E. L. Thorndike, *Psychology of Algebra,* New York: Macmillan, p. 372.)

from start to finish at a constant rate, and then repeated at fixed intervals until mastered. The time required when repetitions were made at intervals of twenty minutes or more was much less than the time required for nearly continuous study. Most other evidence available

on this point indicates also that distributed practice is economical.

The Distribution of Reviews.—When material has been learned sufficiently to be recalled, how should further practice be distributed when it is desired to have the facts permanently learned, as is often the case with certain facts in history, poems, rules of grammar, combinations in arithmetic, and the spelling of words?

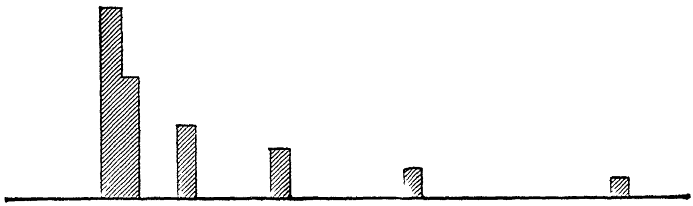


FIG. 41.—FIGURE SHOWING A BETTER DISTRIBUTION OF PRACTICE FOR AN OPERATION IN ALGEBRA THAN THE ACTUAL DISTRIBUTIONS FOUND IN THREE BOOKS AS SHOWN IN FIG. 40. In this more ideal arrangement, the operation is gotten well under way during the first two weeks and thereafter reviewed for periods of decreasing lengths of time at increasing intervals. (From Thorndike, *op. cit.*, p. 371.)

Should the overlearning be carried out at once or should it be distributed over periods of weeks or months?

The evidence bearing on this problem is insufficient to justify a confident statement, but it indicates that one should overlearn somewhat at the beginning and leave the remainder of the overlearning to reviews at constantly increasing intervals. For example, the first review, a relatively long one, should be made within 48 hours; the next review, somewhat shorter, a week later; the next, shorter still, three weeks later; the next, two months later, followed by other reviews at intervals of five months or more.

Actual counts of the frequency and distribution of particular facts in textbooks of history, arithmetic,

algebra, etc., show that usually little attention has been given to effective organization for learning in these respects. (See Figures 40 and 41.) Some of these books concentrate practice almost entirely at one point; some have reviews with too long gaps between; many show a haphazard arrangement, differing greatly for different facts presented in the same book. Careful organization with respect to the amount and form of distribution of practice adds considerably to the task of constructing texts but subtracts greatly from the learning task of students.

The Whole Versus the Part Method.—If a person were given a lesson of substantial size to memorize, he might master it part by part or read it as a whole. The fact that repetition of an item at intervals is a more effective method of learning than concentrated repetition gives the whole method some advantage, since learning a long piece of poetry, for example, results in longer intervals between repetitions of a given line than when the material is learned in smaller units. Several other advantages probably more important are inherent in the whole method. The attack is usually more active for one thing; the short unit seems to result in a more superficial manner of study; certain types of reaction—such as getting the meaning of the whole, observing the development of the thought, and the recurrence of similar ideas—are more adequately secured. The sectional method often enlists more artificial connections, such as those with position in each stanza. These may later be the source of confusion, since the first lines of several stanzas are recalled on the basis of being in first position. The part method introduces certain misleading connections. For example, when the first stanza is finished, the learner goes back to the beginning of the same verse with the

result that the end, instead of being connected with the beginning of the next stanza, is connected with the beginning of the first. Hence children often get "stuck" at the beginning of a stanza which they can recite readily once they can secure a start. The main advantage of the whole method, then, lies in the fact that the connections are formed in the way they will later need to function. This, with the advantages secured by the length of the lesson and the better distribution of repetitions, makes the whole method, in general, a more economical procedure for study.

Many investigations, in terms of the amount of time required to learn, have borne out the advantage of the whole method. A sample result is shown in the accompanying table.

WHOLE VS. PIECEMEAL LEARNING OF POETRY

(From Pyle and Snyder)

Number of Lines	*Part Method Time to Learn*	*Whole Method Time to Learn*	*Percentage of Time Saved by Whole Method*
20	16′ 12″	14′ 17″	12
30	27′ 23″	23′ 53″	13
40	38′ 44″	35′ 16″	9
50	48′ 31″	43′ 53″	12
60	81′ 10″	63′ 38″	22
120	168′ 55″	139′ 35″	17
240	431′ 20″	348′ 00″	19

On the whole, the advantage of learning by going through the material from beginning to end each time is greater for the long than for the short lessons in this study.

The whole method shows its superiority in recall some time after the original learning more conspicuously than

in the saving of time in the process of fixation. The following table is illustrative:

Recall of Poetry Learned by Whole and Part Method

(From Larguier des Bancels)

	Learned by Part Method	*Learned by Whole Method*
Number of words recalled after one week	26.6	40.6
After two years......................	6 4	16.6
Per cent recalled after two years.......	24	40

The whole method shows to advantage in memorizing poetry, prose, vocabularies, lists of words, and non-sense syllables—and probably in most materials which are to be memorized in serial order. In learning by reading (history, etc.), the relative merits of whole and piecemeal methods have not as yet been demonstrated, but it is probable that reading a lesson through as a whole is distinctly advantageous.

Either in memorizing or reading, the whole procedure should not be adhered to slavishly. Difficult and important sections should be given more attention; easy or unimportant matter "skimmed."

Complicated dance steps, musical selections to be played or sung, and many industrial operations fall within the serial type of learning which may be practiced as a whole or in parts. In an inventory of methods actually used by one hundred prominent musicians, fourteen reported that they employed the whole method exclusively, another fourteen combined the whole and the piecemeal procedure, while the remaining seventy-two learned mainly bit by bit. These data throw little light on the merits of the methods inasmuch as highly competent performers in every field often employ uneconomical methods. Crucial investigations in the case of such func-

tions are lacking. Theoretically, the whole method would seem to possess the same merits here as in the case of memorizing poetry or prose. One investigator (Peckstein) found, however, than in learning certain motor acts, such as tracing the course of a complex pencil maze while blindfolded, the whole method was uneconomical. When the task was extremely difficult, subjects were sometimes unable to learn at all by the whole method. These findings illustrate the risk involved in widespread applications of facts found in one field to situations encountered in others. This study, made upon a rather unusual function not much like motor tasks of ordinary life, offers little evidence against the superiority of the whole method. Nevertheless we must await the results of further investigations to determine the relative merits of the whole and the part methods in the field of motor learning.

QUESTIONS AND EXERCISES

1. Does insight into methods of learning and the detailed operations during performance necessarily result from the possession of great skill in a function? Can you recall instances of great athletes, musicians or artists who were poor teachers. Are fine scholars necessarily good teachers? Are they more or less likely than poor scholars to be good teachers?
2. Explain just what you do when you whistle? Study your vocal organs while whistling to see if you can learn facts about the activities involved that were not known by you before.
3. Apply the facts given in the text to the teaching of some athletic or recreational skill. Compare with methods you have observed in use.
4. Which is better practice for the varsity crew, rowing in indoor machines or rowing on the water? Explain. Which is better practice for the baseball team, practicing catch, grounders, batting, etc., separately or when playing actual games? Explain. Aside from playing actual games, what supplementary work is

desirable? To what extent will throwing baskets in basketball from a stationary position increase ability to toss baskets during active competition.

5. Explain why learning to read German does not enable us to write it or to understand spoken German. Would it be wise to learn in one way or another according to our need to read, write, speak or understand it when spoken?
6. Why is it that some people have difficulty in understanding a passage when they read it aloud to a group?
7. Why is it that a person's voice often sounds quite different when (a) reading aloud, (b) reciting, (c) just talking?
8. How would you teach a child to write English compositions? Show how the principles offered in the chapter apply?
9. Would it be worth while to have the child copy good compositions written by others?
10. Can you offer any example of the use of "crutches" in the learning of the school or everyday life? Of the formation of irrelevant habits?
11. Would you present in spelling lesson the common misspellings of difficult words along with the correct form? Would you say to a child, "You wrote *meashure*. The correct spelling is *measure*," or simply say the word was misspelled and give the correct form?
12. Try this experiment on three different groups. Ask them to guess the length of time which passed between signals. You will say "Ready!", and in a moment "Now!" Then allow an interval of 10 seconds, at the end of which you again say "Now!" The members of the group then write their estimate of the interval in seconds. Repeat with other intervals such as 6, 8, 15, 14, 10, 18, 9, etc., until 30 trials have been made. With a second group, use the same intervals and the same number of trials, but after each trial say: "The time was more than 10 seconds" or "less than 10 seconds" as the case may be. To a third group, state the exact length of the interval after each trial. Compute the improvement for each group. Compare and explain the results.
13. Should the writer attend to the feelings in the fingers or the written product? The singer to the "feel" in the throat or to the vocal product?
14. Taking into account the facts concerning recitation vs. reread-

ing, the distribution of intervals in learning and review, the whole vs. the part method of study, plan the most effective method of study for this course in psychology.

15. Can you see any advantages in taking but few notes during a lecture and writing out a full account later, in comparison with taking very full notes during the lecture and reading them over later? Could you test these or other methods experimentally?
16. Suggest ways of using a recording phonograph or a moving picture camera to assist learning in one or more functions.

GENERAL REFERENCES

H. D. Kitson, *How to Use Your Mind; A Psychology of Study,* Philadelphia: Lippincott, 1916; G. M. Whipple, *How to Study Effectively,* Bloomington, Ill.: Public School Publ. Co., 1916; E. L. Thorndike, *The Psychology of Arithmetic,* New York: Macmillan, 1921, and *The Psychology of Algebra,* New York: Macmillan, 1923; A. I. Gates, *The Psychology of Reading and Spelling with Special Reference to Disability,* New York: Teachers College Bureau of Publications, 1922; F. C. Ayer, *The Psychology of Drawing,* Baltimore: Warwick and York, 1916; F. N. Freeman, *Visual Education, A Comparative Study of Motion Pictures and Other Methods of Instruction,* Chicago: University Press, 1924; Daniel La Rue, *The Child's Mind and the Common Branches,* New York: Macmillan, 1924; T. H. Pear, *Skill in Work and Play,* New York: Dutton, 1924.

REFERENCES TO STUDIES UTILIZED IN THE TEXT

F. Gilbreth, *Applied Motion Study,* New York: Sturges & Walton, 1917.

A. I. Gates and G. A. Taylor, "Acquisition of Motor Control in Writing by Pre-School Children," *Teachers College Record,* Nov., 1923.

G. Myers, *A Study in Incidental Memory,* New York: Columbia Univ. Archives of Psychology, about 1910.

A. I. Gates, *Recitation as a Factor in Memorizing,* New York: Columbia Univ. Archives of Psychology, 1917.

H. E. Jones, *Experimental Studies of College Teaching,* New York: Columbia Univ. Archives of Psychology, 1923.

W. H. Pyle, *Psychology of Learning,* Baltimore: Warwick and York, 1921, p. 40 f.

Henri Pieron, "Récherches experimentales sur les phénoménes de mémoire," *L'année psychologique*, 1913.

W. H. Pyle and J. C. Snyder, "The Most Economical Unit for Committing to Memory," *Journal Educational Psychology*, 1911, p. 133.

J. Larguier des Bancels, "Méthodes de memorisation," *Année psychol.*, 1903, p. 131.

L. A. Peckstein, "Massed vs. Distributed Effort in Learning," *Journal Educational Psychology*, Feb., 1921.

CHAPTER XIII

PERCEPTION

Perception is a type of conscious reactivity and percepts a type of conscious response that may be discussed from several points of view. In the study of brain activity, in an earlier chapter, we found evidence that provided a distinction between a percept and a bare sensation. The percept is the awareness of an object, condition or complex event whereas the sensation is the awareness of a quality, such as red, sweet, or pain. In the chain of conscious reactions, the sensation precedes the percept, and is dependent on different central neurones, although the neurones of the two are intimately connected and the time interval between sensation and perception consciously imperceptible. In the discussion of native traits, we observed that, while the capacity to acquire percepts is native, our particular percepts must be built up during experience. Percepts, then, are reactions acquired during the acts of perceiving or during perceptive reaction. There are typical errors and difficulties and rules for economy in perceptual learning as in other forms; indeed, the main principles of economy are the same. There are, however, a number of facts about perceptive learning and about well established perceptive reactions that merit special treatment in this chapter. We shall begin with a description of the gradual development of a percept.

THE GROWTH OF PERCEPTS.

Facts, in the first place, result from sensory perception. They are the outcome of visual, auditory, tactual, and other sensory experiences with things and events. Typically the percept, which as we have previously observed is a complex conscious reaction, is built up by reacting consciously to many stimuli acting at once. For example, a child on its second birthday is presented for the first time with a puppy. At first the little dog is perceived in a variety of ways. It is a small dark thing which runs about—sometimes dangerously near—with four legs; a thing which barks, whines, scratches the door, and sounds "pat, pat, pat, pat" when it runs; a thing which likes to eat and frolic. Gradually these various conscious reactions become connected with many different stimuli, so that to any one stimulus a joint response, the percept, may occur. Thus, when the child sees only a head or a tail, hears a bark, a whimper, or "pat, pat, pat" on the floor, or feels a moist nose or a shaggy back against his hand, he promptly becomes aware of the puppy.

Trial and Error in the Acquisition of Percepts and Ideas.—The child's percept of the puppy is a complex conscious reaction which is constantly undergoing change by additions and subtractions of the elements which constitute the whole. In this development of the percept the trial-and-error form of learning is apparent. The child at first perceives the animal and proceeds to deal with it much as he would with other objects with which he is familiar. He observes legs somewhat like those of his toy chair, and seizing a leg by which to carry the puppy about, the child's idea is modified by the painful consequences. If the child squeezes the puppy too

affectionately, as he might a stuffed animal, the yelp or possibly a snap results in the elimination of part of the old way of perceiving the pup, and the addition of new factors. The dog, in the course of time, is perceived and thought of as an object with sharp teeth, a certain weight, great strength and agility, a thing that mustn't be stepped on or immersed head first in water, which barks at birds, snaps when disturbed in feeding, and never talks, but is generally a playful companion. The child's idea of a dog is a changing, growing complex of particulars.

Analysis and Combination in Perception.—In the development of percepts two processes are going on simultaneously. The complex object is, on the one hand, analyzed; the minute and subtle features are perceived. Little details of the dog's appearance and behavior are noticed. The shape of the pup's ears, the number of toes, the significance of slightly different whines and barks, the characteristics of its fears and angers are observed more and more specifically. Perception, and consequently thought, becomes progressively more detailed and refined. At the same time, a process of synthesis or building up is apparent. Perception becomes not only more refined, but also more broad and inclusive. The minute facts become combined into percepts and ideas more rich and comprehensive. Analysis and synthesis go on simultaneously and continuously so long as the child continues to disentangle new features of dogness, so long as he continues to observe new details. If, as a young adult, he undertakes the study of anatomy, physiology, or biology, his percepts and ideas of a dog will become greatly enriched. From the childhood percept of a queerly shaped hairy thing the dog's body will be perceived as an amazing complexity of intricate organs and functions. The percept, then, is a constantly grow-

ing complex of integrated particulars. It occurs as a single response but a great many facts are implicit in the reaction.

Perception of the Qualities and Characteristics of Things and Events.

We have illustrated briefly the development of a percept of an object,—a puppy. We found that the apprehension of the object becomes at once more inclusive and more detailed. The percept of a thing always includes the awareness of its qualities and characteristics. As the percept grows, more and more of the features are singled out, and at the same time integrated with others to form a single apprehension. There are two matters that should be investigated a little further. One is the process of singling out, of analyzing a subtle quality of characteristic, to a point where it may be perceived alone; the other is the nature of the stimuli which act when we perceive a complex fact.

The Development of a Percept of an Abstract Quality.—The boy's dog is perceived as an integration or unified collection of many qualities and characteristics such as height, weight, color, flesh, hair, strength, sociability, etc. All of these characteristics are implicit in ordinary perception of the dog. The dime which you see on the table may be analyzed into brightness, hardness, roundness, solidity, value. To perceive the dime is really to apprehend at once a certain combination of these qualities. Not only do we perceive all of these characteristics together as a dime but we learn to perceive each of these qualities—which is usually called an *abstract* quality or *abstraction*—by itself. That which is perceived may later be recalled, *i.e.* may become an object of thought. A tremendously important human charac-

teristic is the capacity to think of many of these qualities quite independent of the setting in which they are perceived. We can come to think of the quality of roundness, area, or honesty, without thinking of the concrete situation in which the qualities have been observed. The character has been torn out, disentangled, abstracted during the process of perception from the other details among which it was perceived. This process of perceptive analysis is usually slow; a trial-and-error procedure just as the perception of an object is. It depends chiefly upon the perception of the quality, say *squareness,* in a large number of different situations—tables, blocks, cards, etc. When the abstract quality has been encountered in only one or a few situations, it is likely to remain imbedded in the larger unit. A mother—to illustrate—had attempted to teach her child the meaning of square by presenting the top of a box which was displayed while the word "square" was repeated and explained. When the father was told of the lesson, he held up a paper, asking "What is this?" "A paper," was the response. "Yes, but what kind of a paper?" "A white paper," etc. No effects of the lesson could be secured by the use of cards and other objects, but when directly asked "What is a square?" the child ran to the box, exclaiming proudly, "That is a square." The element of squareness had not been abstracted. It had not been perceived as such but only rather vaguely as a feature of the box situation. To develop the idea of squareness, one must show the child many different gross totals which contain it, such as a square card, a square desk, a square block, a square board, drawing, picture, etc. When many different situations are presented, the squareness element cannot be easily or immediately associated with them all, and it is unlikely that it will become associated with any one since it is so

slightly connected with each. Eventually squareness comes to be thought of as an independent fact not tied up with any particular situation and it is, therefore, called an abstract quality.

This human ability to develop percepts of the qualities, characteristics, relations and other abstract features of things and events is of great importance. Such an analytic capacity enables us to get at the heart of matters; to perceive and think of facts more subtle than gross things and happenings. It enables us to apprehend more subtle signs of circumstances, signs which indicate a further line of action to be taken. Man's relatively successful management of affairs may be attributed in large measure to his ability to apprehend such abstract facts as gravity, weight, danger, triangle, honesty, liberty. None of these qualities is a particular or concrete thing; each is a characteristic of many different things. The life of thought is filled with notions of these sorts. Test this statement by observing, in the last few lines of this paragraph, the relatively large number of words which stand for abstract qualities, relations and other characteristics compared to the number that represent concrete things.

Summary.—The process of perception is both analytic and integrative. Our percepts of objects and events become more rich and inclusive as they become more detailed and refined. We acquire gradually percepts of broader and more inclusive things and at the same time percepts of the component characteristics—weight, size, distance, beauty, value—of things. Often the quality is perceived as intrinsic in the thing as when we see a big or distant or pretty object. Yet these qualities through extensive experience come to be appreciated as such; we achieve a notion of bigness or distance or beauty as an abstract fact.

The Stimuli to Which We React in Familiar Forms of Perception.

The Ease of Practiced Perception.—The acts of perceiving concrete objects and events, dishonesty or beauty, in a person, size, weight, position or distance of an object become so thoroughly practiced in the course of life that they seem to involve no activity on our part at all. We can scarcely realize that such percepts mean a complex reaction by us. They seem, almost, to be impressed upon us from without. We shall be able to understand the active nature and complexity of practiced perception if we give a little more attention, first, to the variety of stimuli or signs to which we react and, second, to many ways in which our perceptive responses may be incorrect and incomplete.

In most everyday types of perception leading to most obvious types of facts, it is usual to find that the response is really complex and aroused by a large number of very subtle stimuli or signs. Of most of these signs we remained ignorant until they were disclosed by elaborate investigations. In the case of some of the most matter-of-fact percepts, the stimuli still remain unknown. These facts are very well illustrated in the perception of the distance and position of objects, a form of perceptive ability acquired very early in life and therefore, presumably, one of the easiest and simplest types of perceptive reactions.

Visual Perception of the Position of Objects.—The child soon learns to perceive at least approximately the position of objects in space. He perceives now that his dog is at his feet, now that he is at a distance behind a chair, again that he is more distant down the street. The child, or the adult for that matter, rarely gives a

thought to the clues by means of which he comes to perceive the position and distance of objects in space. Nothing, it would seem, could be more simple; one merely perceives that the tree is near and the mountain distant. Yet such perceptions are tremendously complex processes and the identification and disentangling of the elements involved has been a striking achievement in science. The analysis of the process is interesting and valuable not only in its own right but also because of its implications for other types of human perception.

When the eye is exposed to the light waves reflected from the landscape, an image is formed on the retina much as it is formed on the plate of a photographic camera. It is a flat image, without depth, the third dimension of space. The individual, of course, really *sees* with his brain, although the activity of the eye is an essential step in the process, and he sees things at different distances, not as if painted on a flat canvas. He sees things at different distances as the result of a number of very subtle stimuli, all acting together in a characteristic way. One factor is the size of the image which the object casts on the retina; the nearer the object the larger the image. Another stimulus is the clearness of outline and detail of an object; the nearer the object the more distinct and detailed. A third is the color of an object; the colors of nearer objects are not only more vivid but they are different in quality, the reds and yellows fade with distance leaving distant objects more predominantly bluish or purplish. A fourth factor is the appearance of shadows; those of nearer objects are not only more distinct but of a different shape than the more distant. A fifth is the cutting off of parts of the distant objects by the near objects in the same line of vision. A sixth stimulus is produced by the muscular activities of

gulating the lens of the eyes to focus the object, the novements of accommodation" as they are called. When ιe object is near, the muscles contract in such a way at the lens becomes more thick or bulging; when the ject is distant, the muscles relax with the result that e lens becomes more thin and flat. Accommodation for jects at any distance more than 50 feet is the same. seventh stimulus results from the movements of conrgence of the two eyes on a single object. When the ject is very near, the external eye muscles pull the eyells so that the corneas of both eyes are turned toward e nose; as the object becomes more distant the eyes are oved back until, at a distance of three or four huned feet, the lines of regard from each eye to the object e parallel. An eighth stimulus results from the relaıns of the two images of an object, one in each eye. you close one eye, you still see the object, so, of urse there is an image in each eye. Now, these images e not precisely the same, and the differences become clue to the distance of an object. To illustrate, hold our finger upright about five inches in front of the ose, and look at it first with one and then the other e closed. The differences are considerable, becoming ss as the object becomes more distant. A ninth stimus is produced by the really discrete, but apparently sregarded double images of things nearer and more stant than the object fixated. If you have three obcts—a near one A, a middle one B and a more distant ne C, and focus your eyes (also your attention) on B, will be seen as one object, but A and C are seen sepately by each eye. More than that, the near object, A, seen on the left of B by the right eye and on the right the left eye, whereas C appears on the same side of as the eye which sees it. You can try this out by

holding up a finger of one hand about five inches and a finger on the other hand about ten inches in front of the nose. First fixate the near finger, and without releasing this focus, you can see a blurred double image of the distant finger. Now alternately close a single eye. Repeat by fixating the distant finger. Other clues by which the distances of objects are perceived are obtained when the head is moved. If you look into a clump of trees, and swing the head from side to side while fixating a tree within the group, you will observe that the nearer trees seem to move in the opposite direction from, while the distant trees move the same direction as, the movement of the head.

The perception of the distance and position of objects reveals two important facts:

(1) The fact that any apparently simple percept is the result of a large number of different stimuli acting together.

(2) That we may perceive very well without knowing how it is done, with little or no awareness of the clues utilized, of the stimuli at work.

Both of these statements are true of many other types of perception and judgment and of other acquired reactions as well. One may be able to perceive well such traits as beauty, symmetry, weight, honesty, or to perform well on a violin, bicycle, or typewriter without knowing how one acquired the ability or how one performs at any time.

The Perception of the Location and Distance of Sound.—The stimuli which enable us to perceive the distance and position of objects were mentioned because they are better known than those for most other types of perception. The position and distance of a sound is more difficult to perceive and we are less certain how it is

perceived. Variations in the intensity and quality (timbre) of the sound are doubtless clues for distance; and the relative force with which the stimuli affect the two ears are signs of direction. If you test a blindfolded subject with a snapper sounded in various positions in a plane equally distant from the two ears, before, above and behind the head, startling errors will appear. When the sound is moved to one side of the plane it is more readily located.

Perception of Position on or in the Body.—The perception of location of a stimulus on or in the body is a puzzling matter. How do you know that the stimulus—prick, pressure, cold, etc.—affects your toe rather than your hand; how do you perceive that the pain is in your knee rather than in your stomach, when as a matter of fact, these sensations are due to activity in the cortex of the brain? So completely have we taken these percepts of position for granted that the questions seem almost absurd. Nevertheless, no one is able to answer them and science ascribes them either to as yet unanalyzed "local signs" (i.e., sensory qualities arising from the sense organs stimulated) or to the sensory qualities of reflexes set up by the stimulus. Both explanations are hypotheses and not demonstrated facts.

Perception of Human Characters.—In the perception of human traits such as initiative, honesty, humor, and the like, the signs to which we react are usually as numerous and obscure as the stimuli which determine our apprehensions of distance, or position or beauty of a house. Some of the known facts concerning social perception will be presented later in this chapter.

"Intuition."—The term intuition is sometimes applied to types of percepts no more mysterious than the perception of distance. "I know by intuition that this man is

not altogether trustworthy." "I dislike that man, but just why I do not know." "I feel as though I were catching cold." "Something tells me that it is going to rain." These are representative statements of common situations in which we perceive, but do not know by what particulars the percept is occasioned. Sometimes it is an obscure feature, such as a curious look about the eyes or mouth, which suggests dishonesty; sometimes many stimuli acting together such as various unlocalized sensations from the body result in the impression of impending illness, or the unanalyzed effects of dampness, chilliness, and other atmospheric conditions, may occasion the idea of rain.

These unintelligible ideas are of the same order as the ordinary perception of distance or time. They are no more unnatural and doubtless no more complex than many other types of perception. The fact that the causes of the idea are obscure and unanalyzed gives such reactions no claim to a special term such as intuition. They should be classed with many other types of perception that are as yet not reduced to their elements.

Summary.—The classes of perceived facts are innumerable. We perceived the sizes, shapes, locations and distances of objects; expressions of anger, grief or determination in face or body; we perceive cloudiness, dampness, hardness, stiffness, aboveness, number, pattern, weight, closeness, justice, cruelty, metal-ness, sturdiness, harmony and so on for an endless list of facts of which we become aware by means of stimuli affecting one or more sense organs. That the particular percepts are acquired as a result of experience more or less extensive, that percepts change as our experiences continue, that the activating stimuli are often exceedingly complex and not consciously appreciated as such by the subject, have now

been in some measure illustrated. Next, some attention will be given to the accuracy of usual and unusual adult perception.

INACCURATE PERCEPTS AND ILLUSIONS.

Although we know very little about the stimuli which activate many of our percepts, we usually trust our observations; indeed, we probably are, on the whole, too insensitive to our errors. Inaccuracies and inadequacies pervade the whole field of perception although they vary greatly in amount and most of them have no serious consequences under ordinary conditions. Exigencies, however, may arise, as in legal cases or medical diagnosis, or in science, when accurate percepts alone are admissible and inaccurate observations may be serious or fatal.

Errors in perception may be due to several types of causes:

(1) To irregular or unusual conditions in the external world;

(2) To defects, inadequacies or peculiarities in the human sense organs;

(3) To inappropriate operation of the human perceptive mechanisms due to native limitations, to inadequacy of training, to the character of established habits of expectation, or to misleading interests or attitudes.

When the errors of perception are large or striking they are usually called *illusions*.

Errors due to Unusual Conditions in the Natural World.—A stick thrust partly into water, appears bent although it is really perfectly straight. This error is due to the peculiar way in which light waves reflected from the stick are refracted in their course to the eye. Seeing the stick as bent is a false perception, or an illusion. It is not due to a peculiarity in the eye nor to an inade-

quacy in the perceptual habits of the observer, but to a peculiarity in nature. Seeing one's face in a mirror, is in a sense an illusion due to causes outside the observer, but it is one of those errors of perception which we correct in the making. To some primitive peoples, such an illusion is at first dumbfounding. In some sections, mountains look much more distant some days than others, due to the influence of atmospheric conditions. Such errors, or variations in perception are rarely preventable but they may at least be detected so that allowances for them may be made.

FIG. 42.—MOVE THE BOOK SO THAT IT IS GIVEN A CIRCULAR MOVEMENT WITH A RADIUS OF ABOUT ONE INCH. If this figure is reproduced on a round card which is then spun on a hatpin stuck through the center for about ten seconds, then suddenly stopped, a most interesting illusion occurs. As you continue to look at the spiral it will expand or contract, depending on the direction of rotation. (Reproduced by permission of D. Van Nostrand Co., from M. Luckiesh's *Visual Illusions*.)

Errors Due to Peculiarities or Inadequacies of the Sense Organs.—Our sense organs are very useful instruments but they are not adequate to meet all of the demands made upon them. If a witness in court declared that a sound was heard directly behind him, rather than in front of him, he might well be in error, since the ears are incapable of providing correct perceptions in this plane. If one looks at a waterfall or at falling snow for a time and then looks at a motionless landscape or wall, objects

will appear to move upward, due to a persisting influence which disturbs correct vision. If you give Figure 42 a circular movement of a radius of about an inch a most curious illusory percept results. If a similar spiral is spun around at a fair rate for ten seconds or so, the after-effect is even more startling. Visual after-sensations and contract-effects are examples of this type of illusion. Vertical lines seem longer than horizontal lines; a filled interval seems longer than an unfilled in space as in the figure below.

Two points about a half inch apart are readily perceived as two on the palm or lips, but when applied to the back they feel like a single point. These are samples of the many instances in which our percepts are really in error due to limitations of our sensory apparatus.

Errors and Illusions Due to Central Perceptive Processes.—The innumerable errors and illusions due to the central perceptual mechanisms may themselves be subdivided. Some are due to taking into account only a part of the data required for a full and correct perception. The car window illusion is of this type. If your car is motionless while another within sight starts in the opposite direction, you may erroneously decide that you are going forward. The movement of the field of view in the opposite direction is only a part of the adequate stimuli for this percept. On the other hand, if your car starts with unusual smoothness, you may wrongly perceive the other car to be in movement in the opposite direction. In this instance, the trouble appears to be in the obtuseness of .the sensory apparatus for detecting

movement. In both illusions, however, expectation plays a considerable rôle. If some incident leads you to expect the stationary car to move first, you are much more likely to be subject to the illusion.

Influence of Expectation.—Expectation is a potent influence in many illusions and errors of perception. It leads us to mistake a shriek of wind for a human cry, a white garment for a ghost, a small tree for a man in the darkness. An erroneous report was once circulated to the effect that two children had been carried down the Hudson River on a cake of ice. Many people, crowding the shores at various points, mistook what was really two bushes on the ice for children because of the anticipation of such an appearance.

The influence of the attitude of expectation in facilitating percepts congruous with itself but incongruous with the actual facts is brought out vividly in laboratory studies of "suggestion" (such as those performed by Warner Brown). College students were led to believe that the purpose of these experiments was to measure the sensitivity of their senses. They were given a preliminary test in which they reported when they first felt the tingle from an increasing electric current passing through the fingers. Then, they were told to try it again. The setting "suggested" that the current would again be applied and they consequently adopted an attitude of expectancy. On the second test, the current was really cut off by opening a concealed switch, but nearly all of the subjects soon reported that they felt the current again. Similarly, they were led erroneously to report warmth in an unheated box with a big electric light on top; tastes of several sorts in distilled water; odors in odorless liquids; pressure on the hand when none was applied; differences in weights or in the length of lines

according to expectation when no differences existed and so on.

Such erroneous percepts are quite familiar to the physician. After having read some vivid descriptions of the symptoms of diseases, many people begin to perceive these symptoms which were quite unnoticed before. Doctors receive patients who report pains and symptoms which are really illusions; indeed, the physician must be the alert, lest he make the mistake that has been made, of administering treatment or conducting an operation for troubles that are entirely illusory. These erroneous percepts are quite possible, since, if we give our attention to them, curious sensations may be experienced at almost any point and, as in the suggestion experiments, they may be greatly magnified or appear in quite illusory form thereafter.

Establishing a mental predispositions by suggestive words or attitudes is a potent source of influencing perception in many fields. A smiling countenance makes us overlook evil designs; a "jolly up" makes the request to lend money or buy an automobile less unreasonable; the defects of a flattering man may appear almost as virtues while the every act of another with a shifting gaze appears suspicious. In interrogation, as in the court of law, skillful acting or the form of the question may set up attitudes that greatly influence observation or recollection. One investigator found that, after presenting a scene on the screen, the errors in report were greater when any kind of question was asked than when the witness gave a free report. All questions are suggestive, some more than others. The following samples are arranged in accordance with the results of an experiment (by Muscio) from the least to the most productive of error.

Did you see a (gun)?
Did you see *the* (gun)?
Didn't you see a (gun)?
Didn't you see the (gun)?
Was there a (gun)?
Wasn't there a (gun)?
Was the (gun) (big) or (little)?
Was the (gun) (big)?

All of these apply to a case where there was no gun or other object with which the parentheses may be filled. Questions of the more extreme types are what the court calls "leading questions."

Expectations Based on Habits.—The influence of expectation is not always so simple in its operation as most of the previous illustrations indicate. This may be shown by the "size-weight" illusion for which materials may be prepared as follows: Secure a lump of lead about the size of a walnut, and then a piece of light-weight wood or cork to weigh exactly the same. Each should be painted the same color or covered with paper to conceal the materials. If you ask a child to "heft" each and tell which is the heavier, he will usually name the big piece, having been led by its size to expect it to be so. But if you try the test on an adult, he will unhesitatingly declare that the lump of lead is much heavier. Like the child, he expected the bigger object to be heavier, but unlike the child he made a big muscular effort to lift it and a smaller one to lift the smaller object. Because of the unexpected lightness, the big object is judged to be really less heavy than it is while the small weight which turned out to be unexpectedly heavy, is judged to be heavier than it is.

Visual Illusions Due to Inadequate Isolation of Items.—Other illusions may be found which are not due at all

to expectation, but apparently to an inability to isolate an item from its surroundings. Several visual illusions of this type appear in Figures 43 to 48. The Zoellner illusion, of which there are many varieties, illustrates the source of the difficulty and suggests the practical importance of these apparent oddities. The men's legs are straight as may be observed if you isolate them from the other lines by covering the latter with paper or by putting the bottom edge of the page on top of your nose while holding nearly horizontal the page across which you glance with one eye closed. This illusion is merely a rather extreme form of the influence which lines, stripes, squares, and other figure have on the general appearance of book covers, commercial packages, clothing, rugs, etc. Skillful designers utilize such illusory effects to produce stout or slim or other effects. Manufacturers and distributors utilize all sorts of packages, jars, and cans which give the appearance of containing more than they do. In architectural design, the influence of such illusory combinations as appear in figures 45 to 48 must be carefully taken into account.

FIG. 43.—THE LINES ARE REALLY PARALLEL, AS MAY BE SEEN BY TIPPING THE BOOK HELD NEAR THE LEVEL OF THE EYE OR BY APPLYING A STRAIGHT EDGE TO THE SIDES OF THE TROUSERS.

The Art of Deception.—The fallibility of human perception, then, is productive of some good, at least for some people, as well as of annoyance and difficulty to others, such as men of science, judges and juries, physicians and every person who seeks the truth in everyday affairs. Indeed, the inadequacy of perception, especially under conditions of expectation established by suggestion, is bread and butter to some, to many conjurers, quack "doctors," mind readers, ventriloquists, spiritualists and other tricksters. Two dollars may easily seem to merge, when one is hollow and imperceptibly larger than the other; the rabbit may seem to disappear when really it is forced into a container in the bottom of the box so painted as to look deeper than it is; the long nail appears to have been driven through the hand when really another was substituted with a flesh colored curve to fit around the side of the finger. The conjurer's art often consists, as in the experiments on suggestion, of doing first what is desired that the audience should see later. Thus the conjurer picking up the orange from the table, makes a move as if to toss it in the air a time or two and then, having on the last descent pushed the fruit into a trap-door in the table top, makes a rapid thrust into the air. The audience is deceived into perceiving the orange lifted from the table and disappearing into thin air. Under the strain of expectation in the darkness in the typical spiritualistic

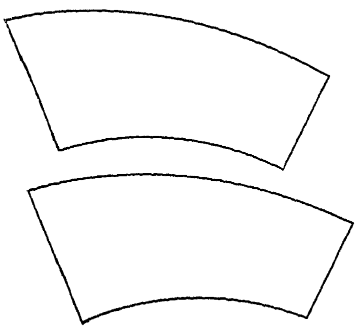


FIG. 44.—AN ILLUSION OF AREA. The two figures are identical in size.

seance, most astounding errors of perception may be obtained.

SOME QUANTITATIVE STUDIES OF ERRORS IN PERCEPTION.

It is of value in many practical lines to detect the types of perception which are unreliable. To bring the limitations of perception to a stage of precise measurement makes possible results even more valuable; results which

FIG. 45.—ILLUSIONS PRODUCED BY THE END-GRAIN OF BOARDS. SUGGEST PRACTICAL USES OF WOOD IN WHICH SUCH ILLUSORY EFFECTS WOULD BE OF SOME CONSEQUENCE. (From Luckiesh's *Visual Illusions*.)

often lead to practical applications not realized at first. Indeed, the quantitative studies of perception illustrate excellently the usefulness to which apparently academic research done in the recesses of the laboratory may be put eventually. The most interesting sample is the study, begun as early as 1825, of the magnitude of the differences between two stimuli of a given kind such as weights, lights, sounds, tastes, etc., which may be perceived with a given degree of accuracy. Essentially this is a study of the relation of the amount of error in perception to the size of the difference perceived.

Weber's Law.—An early discovery in this field of investigation, made by Weber and since known as Weber's Law, is that the difference between any two stimuli which may be barely perceived—the "least perceptible difference," it is called—bears a constant relation to the magnitude of the smaller stimulus. For example, an average person can just perceive the difference between a weight

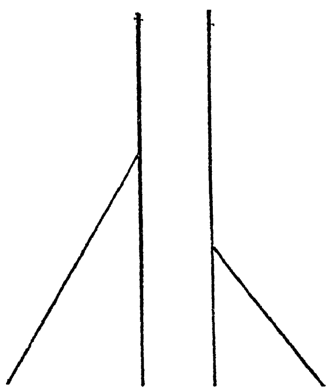


FIG. 46

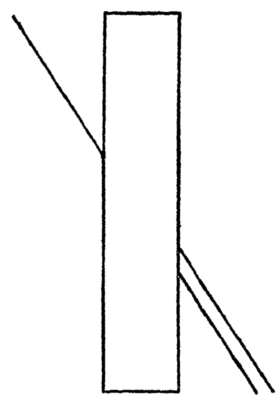


FIG. 47

FIG. 46.—WOULD THE TWO DIAGONAL LINES MEET IF CONTINUED? Test with a ruler. Would such an illusion influence architectural designs?

FIG. 47.—POGGENDORFF'S ILLUSION. Which oblique line on the right is the prolongation of the one on the left? Test with a ruler.

of 100 and 110 grams; the *difference* is related to the *standard* as one to ten. In other words, the difference is one tenth of the smaller or "standard" weight. This relation holds for other weights. If the standard is 200 grams, the difference, to be perceived must be one tenth greater, *i.e.*, 220 grams; if the standard is 300 grams, 30 grams must be added to the 300 before the difference is perceptible, and so on. To perceive a difference in bright-

ness of light, the difference must be one one-hundredth; in the length of a line, one fiftieth; in loudness of a sound one third of the standard. Weber's Law is merely the precise quantitative statement of facts well known in everyday life. We know that the slight blow of a chairman's gavel may be heard in a quiet meeting, whereas only a heavy pounding would be perceptible in a noisy gathering; that the addition of one light to 200 will not be perceived whereas the addition of one to ten will if one

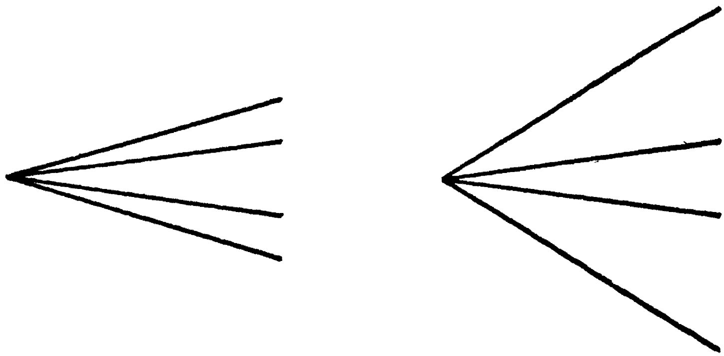


FIG. 48.—THE INNER ANGLES ARE THE SAME IN BOTH FIGURES.

is attentive. The precise relations given do not hold perfectly for extremely small or large standards, but they do hold for a wide middle range.

Weber's Law Extended.—Other investigators (notably Cattell) found that individuals differ in the keenness of their perceptions of differences and that the same individual varies from time to time. If a number of individuals were each carefully tested by a number of trials, and the results for all combined, the outcome is a series of differences, each perceived by varying numbers of times; the bigger the difference the larger the number of times it is perceived; or conversely, the smaller

the difference the larger the number of errors in comparison. A sample result is given in the table below:

THE NUMBER OF CORRECT PERCEPTIONS OF DIFFERENCES IN WEIGHT
(From Cattell and Fullerton)

The standard for comparison is 100 grams

Weight Compared to Standard.............	104	108	112	116
Per Cent of Correct Percepts of the Difference	68	77	88	94

Note that the smallest difference is perceived by but 68 per cent and that the percentages increase as the differences become larger. Note also that the difference between 100 grams and 104 is a difference perceived by 68 per cent of the observers. Suppose now, we test the same group using as a standard 104 grams. We will find that a weight of about 108.2 grams may be perceived as heavier than 104 in 68 per cent of the trials and that if we go on, finding the weight which will be perceived as heavier than the one below it in just 68 per cent of the tests, we shall get approximately this series: 100, 104, 108.2, 112.5, 117, 121.7, 126.6. When examined, this series of weights—the differences between adjoining pairs of which are equally often perceived—obeys Weber's Law. The relations between successive numbers in the series are the same, namely, each is about one twenty-fifth heavier than the preceding one.

Practical Inventions Growing Out of Weber's Work.—It remained for Thorndike to discover the practical use to which such facts could be put. He was trying to find some way in which one might measure differences in the quality of such products as samples of handwriting or drawing. He perceived that if you picked out from a number of samples of writing, a very poor one, then another which just 68 per cent of a group of competent

judges declared was better, and then another which just 68 per cent of the same group perceived as better than the second; and a fourth which 68 per cent perceived as better than the third, and so on, you would come out with a series in which the differences between any adjoining pair were psychologically the same as the difference between any other adjoining pair. The series would form a scale of increasing amounts from the poorest to the best, by equal steps. *The steps would be equal in the sense that the differences between them are, to human observers, equally perceptible.* This is, of course, the kind of equality desired for many purposes.

In constructing such a series of test, it is not necessary to use the steps perceived by 68 per cent of the judges. If a series separated by bigger steps were desired, it could be secured by taking the items perceived as different by 75 or 85 or 95 per cent. The larger the per cent who perceive a difference, the bigger the difference must be. (See again the table above.) How widely separated the steps in the series should be is determined by practical considerations.

Since the time of this discovery, Thorndike and others have produced quality scales for many types of human products—for handwriting, free-hand lettering, drawing of several types, English composition, poetry, mechanical designs, and different types of hand sewing. Samples from the original handwriting scale appear in Figure 49. Scales of these types are extensively used in schools. By matching a pupil's handwriting with a sample on the scale, the teacher can give the pupil's product a definite score. She can tell how many units he is better or poorer than another; can tell just how much he gains during a semester in comparison with others or with his own progress the semester before; she can tell him at

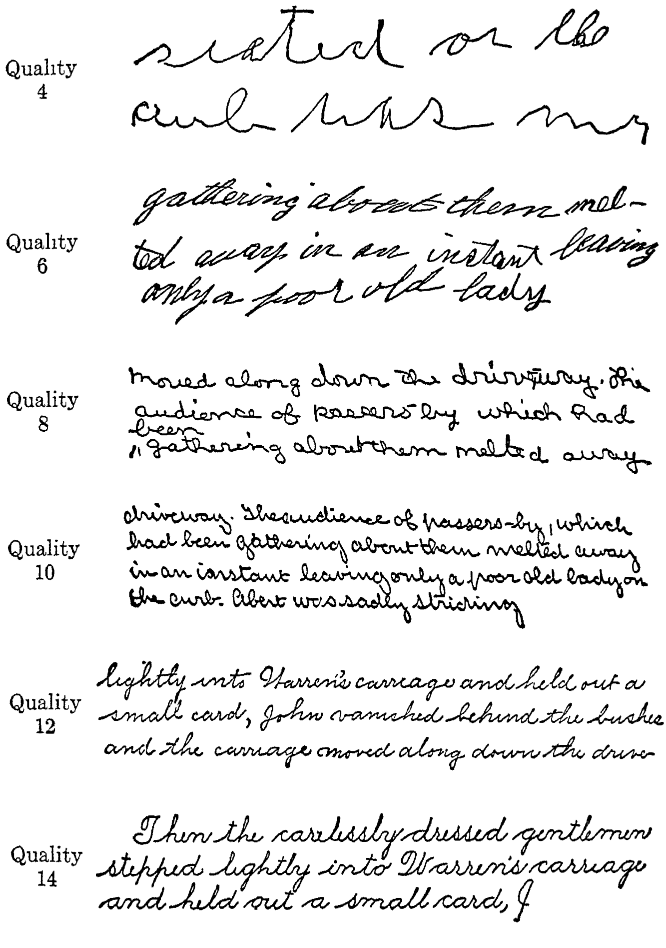


FIG. 49.—SPECIMENS FROM THE THORNDIKE SCALE FOR QUALITY OF HANDWRITING. The samples are greatly reduced in size and only a few of the specimens at a few of the steps are shown. The original includes several specimens for each step from Quality 0 to Quality 18.

the beginning of the year the sample on the scale he is expected to equal by the end of the year and what specimen he must equal before he will be permitted to gradu-

ate from writing drill. Scales of this sort have done much to make the work of education a more refined and effective procedure.

Studies of Perception of Facial Expressions.—A quite different field of quantitative study is concerned with the accuracy of perceiving human expressions. The importance of accurate perception of the symptoms of human attitudes, intentions and emotions in the face is so great that the child is early stimulated to acquire such ability as he may. Father appears from his day's labor at the office with an expression which mother at once perceives and takes into account, modifying her words and deeds accordingly. The child fails to notice the scowl, but when his joyously noisy behavior is met with a sudden reproach, he is forced to a more careful survey of the situation. After many trials and errors, the child learns to perceive a variety of rather subtle features. The learning is slow, however; the average child is five or more before he can, for example, identify the characteristics which distinguish the ugly from the pretty faces, and probably considerably older before inconspicuous evidences of anger, pleasure, annoyance, or sadness are perceptible. The degree to which social perception extends among human adults appears clearly enough in instances which show an unusual lack of it. The individual who does not realize that he is boring when he means to be interesting, amusing when he thinks he is impressive, offensive when he tries to be complimentary, or who does not observe that he is unwelcome in a group when such is the case, portrays one of the most striking failures of perceptive learning.

A beginning has been made in the study of the development of this social perceptive ability from childhood to adulthood by the use of standard photographic reproduc-

tions of facial expressions of various sorts. A set utilized for this purpose is reproduced in Figure 50.

The ability to perceive correctly the emotion or attitude portrayed in the photographs increases gradually with age. The table below shows the average number of expressions correctly perceived by groups of children of the age indicated. The child of seven and a half is able correctly to interpret four of the ten, at eleven about

THE AVERAGE NUMBER OF PICTURES FROM THOSE SHOWN IN FIGURE 50, WHICH WERE CORRECTLY INTERPRETED BY GROUPS OF CHILDREN OF DIFFERENT AGES

(From G. S. Gates)

Average Age in Years	7 5	8.5	9.5	10.5	11.5	12.5	13 5	*College Women*
Average Number Pictures Correct	3 9	4.7	5.1	5 6	6 4	6.7	7.6	8 9

six, at fourteen probably about eight and the average college woman fails on but one in the set, when the scoring is liberal, as under the conditions of the study. Among individuals of approximately the same age or educational status, great differences were found, as shown in the accompanying table.

SHOWING THE PERCENTAGES OF CHILDREN BETWEEN 9 AND 10 YEARS (AVERAGING 9 5 YEARS) AND OF COLLEGE WOMEN WHO CORRECTLY INTERPRETED VARIOUS NUMBERS OF FACIAL EXPRESSIONS OUT OF A POSSIBLE 10.

(From G. S. Gates)

Total Number of Pictures Correct	1	2	3	4	5	6	7	8	9	10
Per Cent of 9.5 *Yr. Group*	3	5	14	20	18	15	14	9	3	0
Per Cent of College Women						2	8	14	46	30

Among the children averaging nine and a half years of age, the number of successes varied from one to nine out

of the possible ten. Some of the nine and a half year children were superior to some of the college women, since the scores of the latter group vary from six to ten. The set of pictures thus provides a rough measure of this type of perceptive ability; an ability of obvious importance in human intercourse.

Perception of Traits of Character.—While individuals differ greatly, the average accuracy of perceiving some of the familiar attitudes and emotions by observing the facial expression is fairly high. When the real face with its movement and color, and the general bodily acts and postures are observed, the accuracy may be even higher although this has not yet been demonstrated. It is very important, however, that we appreciate the limitations of the study of perceiving attitudes and emotions. Perception of these traits is a very different matter from the judgment of traits of character such as trustworthiness, sociability, humor, ambitiousness and such complexes as selling, mechanical and other abilities.

The judgment of attitudes and emotions is but one phase of perception of the broader social and individual traits. Estimates of these broad traits of character are usually very inaccurate. A very fair sample of the results obtained in judging human traits in everyday life after short acquaintance is provided in a study (by Hollingworth) of the achievements of representative commercial employment experts. Twelve expert employment or sales managers interviewed 57 candidates to determine their personal fitness for a particular type of work. Each manager saw all of the men for two hours in the morning while they were being put through certain tests. Then he saw them stand up before an audience when each applicant announced his name and certain other facts. Later each manager interviewed each candidate closeted

in a room where he could be looked over and questioned as desired. Sample results are shown in the table below:

The Roman numerals indicate the sales-managers; the letters on the left indicate the applicants; the number in the table is the position which the sales-manager gave the candidate. The number 1 indicates a candidate was judged to be the best, while 57 means the poorest of the lot.

Sales-Managers

Candidates	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
A	33	46	6	56	25	32	12	38	23	22	22	9
B	36	50	43	17	51	47	38	20	38	55	39	9
C	53	10	6	21	16	9	20	2	57	28	1	26
D	44	25	13	48	7	8	43	11	17	12	20	9
E	54	41	33	19	28	48	8	10	56	8	19	26
F	18	13	13	8	11	15	15	31	32	18	25	9
etc.												

Candidate A is judged to be anywhere from the sixth from the best to the next to the poorest; B from the seventeenth to the fifty-fifth; C from the best to the fifty-third. The unreliability of perception of such vocational aptitude is striking.

With longer acquaintance, the estimates should be better, of course, but the results of studies of ratings made by army officers of various personal and social traits of their men with whom they had been in intimate contact for a year or more were also very untrustworthy. To secure a degree of reliability practically useful, the estimates of at least three officers, each working out his appraisals in a most systematic manner, were essential.

Commercial Systems of Perceiving Character.—Despite the manifest complexity of the task of perceiving human character traits, there are a number of commercialized systems consisting mainly of simple lessons by means of which, supposedly, one is soon able to learn how to perceive various fundamental traits. Honesty, intelligence or executive ability—to give an example—

may be perceived in the physical features of the face and body. These methods are utterly different in principle from ordinary precepts of attitudes and emotions based on the muscular patterns of expression. Such commercial systems assume an innate and universal correspondence between such features as the size or shape of the nose, mouth, chin or forehead, bumps on the skull or the texture of skin and hair, color of eyes, etc., and fundamental traits of character. Careful studies (by Cleeton and Knight) have disclosed the utter worthlessness of most of these criteria. Most of the systems are useless and misleading. This does not mean, necessarily, that the advocates of the schemes or persons who try to use them are poorer judges than the average but it does mean that whatever success they achieve is due to the use of perceptive clues other than those they preach. Like other people, they do not usually know how they reach their decisions any more than they know how they perceive distance or time. Most of us take into account elements of speech and manners, the general physique, facial expressions (rather than features), dress with all the intricacies of style, neatness—all of these and many others. The commercial systems are not the results of scientific analysis, such as those made of the methods of perceiving distance; they are often pure rationalizations.

Perceiving One's Own Traits.—Not only are we rather poor, on the whole, in perceiving the traits of others, we are also often unreliable observers of ourselves. In part, failures in social adjustment are due to inability to perceive one's self properly. It was found in an investigation (Hollingworth) in which each one of a group of college girls judged each of her acquaintances as well as herself for various traits, that those generally recognized by others as the most snobbish, vulgar, or conceited were

very poor judges of themselves in those respects. They apparently did not perceive, as others did, in their own words, deeds and expressions the elements of the undesirable traits. Similarly, those who possessed the least refinement, intelligence, sociability, humor and neatness were rather blind to their deficiencies. They possessed, moreover, inferior ability to perceive these characteristics in other people. Having never achieved clear ideas of what constitutes sociability, neatness, refinement, etc., either in themselves or others, the process of learning came to an early halt. They were like the child learning to write or speak without a distinct model to utilize in discovering successful and erroneous reactions.

Greater accuracy in perceiving one's own traits is to be acquired as other abilities are acquired; the errors and deficiencies are like those in writing and tennis and should be, in a similar way, detected and eliminated. Like detection of many other defects, unless we are well trained in so doing, an experienced critic may be required to help us out. Unfortunately, most of us are considerably more sensitive about errors and defects in character and social behavior than we are about defects and deficiencies in tennis or handwriting, and since we are less likely to be told about our errors we are less likely to discover and correct them.

Economical Methods of Acquiring Percepts.

Many of our percepts are acquired during long periods of desultory trial-and-error experience as described in the instance of the boy and his puppy. Ability to perceive depth, weight, attitudes and emotions in facial expressions, more complex traits of character in the behavior of others or in ourselves rarely is developed systematically and rarely is the subject of direct education.

Other forms of perception, such as reading words, music, shorthand, chemical or mathematical symbols, judging perspective in drawing, understanding a foreign tongue, perceiving qualities of wine, tea, cloth, diamonds or potatoes are sometimes acquired systematically and under tuition as in other forms of learning. The development of ability to perceive the honest, and the moral aspects of situations; to perceive the beauty in music or art; to perceive the significant characteristics and qualities in all types of things and happenings may be desultory or systematically guided. The principles of economy, as described in preceding chapters, apply to perceptive as to other forms of learning.

QUESTIONS AND EXERCISES

1. Trace the development of your own ideas of the term *perception* or of *psychology* during this course. In what respects has it become broader and in what respects has it become more definite?
2. Give a plausible account of the way in which a child learns to perceive *honesty* in behavior. Suggest methods of assisting the child to learn what is honest and what is dishonest. Review Chapters 11, 12 and 13, if necessary.
3. When you next experience some feeling or idea for which you cannot at once account, see if you can discover a simple explanation of the occurrence. Reread pages 289 ff.
4. Hold a small ink bottle a foot in front of your face, with the small end pointed toward your nose. Alternately close one eye and then the other. Draw pictures of the different views obtained. Do the views become more or less alike when the bottle is moved farther from the face? Were you ever conscious of these facts before? In what ways have they probably been previously utilized?
5. Trace the development of your ideas of your college from the time of your arrival. Illustrate trial and error, analysis, and combination.
6. Take the series of pictures of facial expressions and ask children

or adults whom you know well to tell what the woman is doing or what she is thinking about. What are the characteristics of those who do poorly? Are they specially dull, conceited, socially crude, poor in understanding of human nature, lazy, etc.? What particular expressions were most frequently misinterpreted by children? By adults? Explain these results. Do you suppose that most children learn to perceive some facial expressions earlier than others? If so, which?

7. To what practical purposes could a highly reliable test of ability to perceive facial expression be put?
8. Give some additional illustrations of the operation of Weber's Law. Why is it called a law?
9. How does one learn to perceive the significance of the endearing, angry, or nervous voice? Do individuals differ in such perceptive ability? Is this ability important?
10. Record a number of your most startling erroneous perceptions and attempt to explain them.
11. When a person first ascends in a balloon or airplane, he perceives the earth, not himself, to be moving. Explain.
12. Blind people perceive shapes and lengths by use of the hands, and blind people perceive the distance, direction and source of sounds better than normal people whose sense organs are just as acute. Explain.
13. Analyze the conditions of the usual spiritualistic seance. Why is one very easily deceived under such circumstances?
14. What perceptive abilities would be important for a physician, a lawyer, an artist, a teacher, a pickpocket, a huntsman?
15. How would you set about to increase your ability to perceive your own desirable and undesirable traits?
16. Attempt to describe the way the world would be perceived by a person both blind and deaf. What ideas, if any, would such a person be unable to acquire? By what clues could such a person appreciate shape, size, distance, the degree of sunshine or shade, an approaching storm, the passing of a wagon? (For an account of such perceptions see *The World I Live In,* by Helen Kellar, New York: Century Co., 1920.)
17. Is learning to play tennis in any degree perceptive learning? What aspects of the game depend on perception? Can you think of any type of learning that does not in some measure involve perception?

GENERAL REFERENCES

Excellent discussions of illusions and other topics of perception will be found in G. M. Stratton's *Experimental Psychology and Its Bearing Upon Culture,* New York: Macmillan, 1908, Chapters 6, 7, 8, 11, 12 and 13.

In M. Luckiesh's *Visual Illusions,* New York: D. Van Nostrand, 1922, are many interesting cases of erroneous percepts.

In Joseph Jastrow's *Fact and Table in Psychology,* Boston: Houghton Mifflin, 1900, are chapters on "The Modern Occult," "The Problems of Psychical Research," "The Psychology of Deception," as well as on illusions and suggestion.

The perception of vocal, facial and other forms of "social" perception is treated by F. H. Allport, in his *Social Psychology,* Boston: Houghton Mifflin, 1924.

The studies of observation and report in various fields are summarized in G. M. Whipple's *Manual of Physical and Mental Tests,* Baltimore: Warwick & York, 1919, Vol. 2.

The acquisition of abstract qualities and meanings and of ideals, together with economical methods of teaching them are discussed more fully in A. I. Gates, *Psychology for Students of Education,* New York: Macmillan, 1923, Chapter 13.

Further discussions of the methods and results of judging human character traits will be found in H. L. Hollingworth, *The Judging of Human Character,* New York: Appleton, 1922; H. L. Hollingworth, *Vocational Psychology,* New York: Appleton, 1916, and C. H. Griffitts, *Fundamentals of Vocational Psychology,* New York: Macmillan, 1924.

REFERENCES TO STUDIES UTILIZED IN THE TEXT

On the perceptive abilities of children: W. H. Winch, *Children's Perceptions.* (Educ. Psychol. Monog. No. 12.) Baltimore: Warwick & York, 1914.

The experiments on suggestion by Warner Brown are reported in *Individual and Sex Differences in Suggestibility,* Berkeley, Cal., Univ. of Calif. Pub. in Psychol., 1916.

The suggestive effects of questions are discussed by B. Muscio, "The Influence of the Form of a Question," *British Journal of Psychology,* 1916, p. 351.

For an experimental study of perception depending on obscure

clues see G. M. Stratton, "The Control of Another Person by Obscure Clues," *Psychological Review*, 1921, p. 301.

For a fuller account of the method of constructing scales by the method of differences equally often noted see E. L Thorndike, *Mental and Social Measurements*, New York: Teachers College, Revised Edition, 1912.

The data on differences in weight were taken from a monograph, *On Perception of Small Differences*, by J. M. Cattell and G. S. Fullerton, Philadelphia, Univ. of Pennsylvania Press, 1892.

A full set of pictures of facial expressions, of which those appearing in the text are a part, will be found in an article by C. A. Ruckmick in the *Psychological Monograph*, No. 136, 1921. Another series will be found in an article by Antoinette Feleke, in the *Psychological Review*, 1914, pp. 33-41. Reports on the perception of such pictures by children and adults appear in an article by G. S. Gates in the *Journal of Educational Psychology*, Nov., 1923. The Ruckmick and Feleke pictures may be purchased from the C. H. Stoelting Company, Chicago, Ill.

The data on the estimation of abilities in salesmen were taken from an article by H. L. Hollingworth in the Journal, *Salesmanship* (Kresge Bldg., Detroit, Mich.), Dec., 1916. The Cattell and Norsworthy studies are reported by H. L. Hollingworth in *Vocational Psychology, op. cit.*

The experimental study disclosing the inadequacies of the methods of phrenology and physiognomy is reported by G. V. Cleeton and F. B. Knight, in the *Journal of Applied Psychology*, June, 1924.

One of the best studies of the process of perceptive learning is that of W. L. Bryan and N. Harter, on telegraphic language, reported in the *Psychological Review*, 1897, pp. 27-53, and 1899, pp. 345-375.

CHAPTER XIV

REASONING, IMAGINATION AND OTHER TYPES OF THINKING

The term thinking is used broadly to include reasoning, creative imagination, recollection, night dreaming, day dreaming and other forms of reverie. We shall attempt to discover similarities and differences among these types of thinking after we have given some attention to the materials with which we think, to the character of the mental processes revealed by introspection during thinking.

CONSCIOUS PROCESSES FOUND DURING THINKING.

We are dealing with *recalled* facts and experiences in considering thinking. Recall furnishes the raw material or "stuff" with which we think. The first task is to observe the variety of facts that may be recalled and then note the kinds of conscious processes that are found during recall.

What Facts May Be Recalled.—We can recall all sorts of things and events, and the qualities, characteristics and relations of things and events outside of the body. We can also recollect the happenings to and activities of and in our body. By *things* we mean objects, such as animals and houses previously seen, flowers and spices smelled, foods tasted, coins handled, whistles heard. By *events* we refer to activities, movements, changes and happenings in or among objects. By *qualities* of things we mean the weight, size, color, beauty and the like.

Characteristics other than qualities include the speed or direction of movement, the unusualness or meanness of a person's acts, the loudness and angriness of the voices of a crowd. Under *relations* would be included the fact that one object is bigger than another, that one man is the tallest of a group or that one dog runs behind another. By *happenings to and activities of the body* we mean falls and changes of position in space or frustrations and successes in movement, and the like. Under *activities in* the body would be included our emotional and organic experiences, our beliefs and doubts, our purposes and intentions, our interests and attitudes. The possible range of recall is as wide as the world of external things and events which we encounter and the inner life of the organism. Any fact once within our experience may be in some way recalled. All of our experiences are not recallable, of course; many are forgotten as the result of disuse. But hosts of facts are subject to recall and these are the materials with which we think.

Conscious Processes Found during Thought—Images.—As you recall facts of various sorts, what kinds of conscious processes are revealed? What are the characteristics of the "contents of the mind" during recall? This is a problem for introspection. Galton, who first undertook to study this problem by securing the testimony of various persons concerning the contents of their thoughts, found that observers reported several kinds of impression. Most persons could recall visual objects and events which appeared in the "mind's eye." As they recalled the breakfast table, they could "see" more or less clearly plates, faces and other objects; they could also "hear in the mind's ear" the sounds of voices and the clink of glasses; they could "smell" the odor of coffee; "taste" the orange; "feel" the pressure of the fork against

the skin or the movement of lifting the arm. They reported that these experiences were very much like the original impressions received through the senses. Though usually less sharp and clear, less definite and stable, these recalled processes were unmistakably similar to the sensory impressions. While these recalled impressions possess, in general, the qualities of sensations they are obviously not genuine sensations, since they are not aroused by stimuli acting on the sense organs. These sensation-like processes which appear during recall have, therefore, been termed *images*.

Types of Images.—Most observers report that when they recall facts during thinking, recollection, day dreaming or reasoning, images are present. The majority can detect imagery corresponding to every type of sensory experience. Averaging the testimony of many observers, it is found that visual imagery is most frequently found, auditory next, and kinesthetic next. Images of skin impressions, organic sensations, odors and tastes are not so frequent. While a few persons report nearly all kinds of imagery to be nearly as vivid and clear as the sensory experiences themselves, and a few others find all of their imagery to be very dim and vague, the majority find them to be midway between these extremes—much less vivid, stable and definite than the real sensations, but clear enough to permit observation and description.

The Imagery in Recalling Symbols.—Most people, especially educated people, find in the course of ordinary thinking that they recall not only concrete objects and events but words and symbols. Some find that recalled words accompany all or nearly all of their thinking. Some persons report fleeting images of the visual appearance of the words, some experience the sounds of the words, others find the kinesthetic experiences of speaking

the words. A certain druggist reports that when he thinks of "prescription" he does not see an image of a bottle, or a mixture of liquids, nor does he hear the sounds of pouring liquids nor smell a complex odor, nor feel himself stirring chemicals, neither does he see a piece of paper with a written word on it, nor does he mentally see or hear or say the word. What he does recall is a visual image of the symbol ℞. The student of mathematics recalls other signs in common use, + or —. Indeed, most persons find during thinking many recalled symbols. It is usually reported, moreover, that words and symbols are recalled as visual objects, or as sounds or as motor impressions of saying or looking at the word or symbol. Since they come in the form of visual, auditory, kinesthetic or other sensory experiences, they are still images according to the definition.

Individual Differences in Use of Imagery.—While most persons find during recall all or nearly all of the types of imagery, sometimes chiefly one kind, at other times several simultaneously, depending on the fact recalled, there are nevertheless some surprising individual differences. In recalling the very same fact, different individuals may find very different kinds of imagery. This fact was suggested in the discussion of recalling words and symbols; some see the word, others hear it, still others feel it spoken. Some persons, moreover, declare that they can and do recall visual objects, diagrams, and paintings without visual imagery; others recall or compose music without auditory imagery. Musicians, for example, sometimes recall a series of kinesthetic impressions of playing or singing the notes, or the visual forms of the printed notes instead of the sounds. Apparently no one kind of imagery is absolutely necessary to recall any fact. It is found, furthermore, that there is no strik-

ing correlation between vividness of imagery in general and intelligence or ability to think or to do creative imaginative work in any particular line. Intelligent people do not, on the whole, have more vivid imagery than dull. Indeed, experienced mathematicians, scientists and other mental workers, as a rule, seem to have weaker concrete imagery than children.

One of the most surprising facts revealed by studies of imagery is the great difference between certain extreme individuals. Occasionally a person declares that in recalling facts of many sorts, he can scarcely ever detect any but visual imagery; another finds auditory, another kinesthetic imagery almost exclusively. The discovery of these extreme cases during the early days of the study of imagery led to the belief that all people could be sharply classified into "eye-minded," "ear-minded," "motor-minded" and other groups. Later investigations revealed the fact that individuals limited exclusively, or even mainly, to one type of imagery are very rare. Nearly all persons experience at least visual, auditory and motor imagery, and most individuals find other varieties as well, although they use them in different degrees and for different purposes.

The varieties of imagery used by different people to recall the same facts and the apparent tendency of imagery to decrease in vividness in the case of professional thinkers make it not unreasonable to suppose that imagery is not indispensable to the recall of facts.

Image-Less Recall of Facts.—There are some investigators who believe that certain facts are recalled without any imagery whatever. When these observers recall that one thing is bigger than another, for example, they declare that the fact of relative size comes to them without any images of the objects compared or any other

sensory image. Especially in recalling relations such as under-ness or near-ness; abstract qualities and characteristics such as hardness, squareness, faithfulness, five-ness and other complex notions such as energy, heredity, liberty, the fact is said to be unaccompanied by sensation-like images. Some persons declare that they often recall ordinary things and events as mere facts without imagery of any sort. Some assert that *at the instant the fact comes to mind*, there are often no images present, although images of words which express the fact or of objects and events associated with the fact may follow. The fact comes, as it were, in the form of a unique process that one cannot describe. One can only say that he recalls a fact or gets a meaning. The conscious process found is not like an image, or sensation, or emotion or feeling or impulse. It is something different from any of these. It is a conscious reaction, the very essence of recalling a fact, but indescribable. Such reactions are now termed variously, *image-less thoughts,* or *non-sensory ideational processes, or image-less ideational processes.*

Conflicting Views Concerning the Essential Processes in Recall of Facts.—The search for the kind of conscious processes which are responsible for the apprehension of facts has not resulted as yet in satisfactory evidence. The traditional view is that groups of images were sufficient to account for the fact recalled. This view, as we have just observed, is questioned by many investigators who declare that they can recall facts when no images whatsoever are present. Some of those who oppose the view that images are the essential data of thought substitute another kind of mental process, a complex response which results in the awareness of facts. A third view, opposed to both of the above, seeks to

explain the apprehension of facts, the appearance of *meanings*, not in terms of any *kind* of conscious process, but in terms of the *sequences* of processes. In this view, facts and meanings are not found in any mental states apparent in an instantaneous cross section of consciousness. They grow out of the continuity of conscious reactions. A picture of thinking as going on in a mind entirely limited to images and other ideational processes would be quite misleading at least. During our thinking and imagining we are conscious in some degree of bodily sensations, sounds, and perhaps other sensory impressions; we often then experience most vividly feelings of pleasantness or unpleasantness, impulses and emotions of various sorts as well as images and the alleged imageless ideational processes. Even during the most abstract reasoning, the play of processes in the fringe of consciousness may be lively and varied. We know that consciousness is complex during thinking but just what rôle each process plays in the awareness of facts is not known. We cannot at present say whether the recall of facts, then, depends upon some special kind, or on the arrangement or on the sequence of conscious processes. We are forced to take for granted the recall of facts without explaining their structure.

Types of Thinking.

The different types of thinking—reasoning, day dreaming, recollecting, imagining, etc.—cannot be distinguished on the basis of the kinds of imagery or other thought processes found, nor on the basis of the kinds of facts utilized. The varieties of thinking are to be distinguished in accordance with the way in which the recalled facts are employed. To the several ways of dealing with recalled facts (or ideas or thoughts) we shall now turn.

Basis of Classification.—It is possible to distinguish two ways in which thinking may vary. It may vary:

(1) In the degree to which it is a faithful reproduction of past experiences;

(2) In the degree to which it is controlled by some conscious aim or purpose.

In each of these respects, thinking may vary between two extremes, the greatest and the least exactness of reproduction, and the greatest and the least control. In each respect, then, we have a scale of amounts. To define any particular instance of thinking, it is necessary to find its position on each of these scales. When this has been done, nothing more is needed to indicate satisfactorily the character of that particular form of thinking. This is the same as saying that the various forms of thought, such as recollection, imagination and dreams, are not really different in kind but merely in degree. In order to show more exactly the two aspects of thinking, examples which occupy the two extremes of each scale will be described.

Extremely Faithful Reproduction.—Extremely faithful reproduction of past conscious experiences is usually called *recollection* or *reproductive recall.* When you recall a fact, an incident or a series of events as nearly correctly as possible, you may approximate the maximum point on this scale. It is rare that recall is absolutely perfect reproduction of a past conscious experience. Errors and omissions nearly always creep in. But within the limits of human reproductive ability, we may think of a maximum level. Much of our thinking is a relatively faithful sort. In recalling names, dates, telephone numbers, prices, facts of all kinds, and in reminiscing, the facts sought are those previously known.

This extreme may be contrasted with imaginative recall which forms the other end of the scale.

Imaginative Recall.—In reproductive recall, the facts are recalled as faithfully as possible in their details, in the temporal order and in the spatial arrangement or pattern. Deviations from the actual are unintentional. In imaginative recall the temporal order of events, the spatial arrangement, in general, the whole organization of items is different. In recollection, one recalls as faithfully as possible what *did* happen during his last picnic; in imagination, one may think, for example, of what *could* happen at the next. One may *recall* the series of tones in a melody previously heard or the pattern of a dress previously seen, and one may *imagine* a new melody made up of familiar single notes, or a new dress composed of elements of color, fabric and arrangement in new combinations.

Imagination has its limits. We cannot imagine things or events that are completely novel. We cannot imagine a melody not made of notes. The new melody is merely a recombinating of notes which are themselves recalled, that is, sound elements previously experienced. We cannot imagine a new hat not made of color or materials which, in elementary form at least, have been observed before. A person deaf from birth cannot imagine sounds; a person blind from birth cannot imagine colors and shades. The most extreme form of imagination does depend on the *recall* of sensory impressions. It is the temporal order, arrangement and emphasis given to these items which is novel. But by new organization, very different total effects may be produced and the rearrangement may be made in various degrees. Purely reproductive and highly imaginative recall, then, are the two extremes of the same scale between which are many

gradations. Any form of thinking may be placed at some point on this scale.

Controlled and Uncontrolled Thinking.—*Dreaming* is the extreme form of uncontrolled thinking. At the opposite extreme of this scale is highly controlled thinking typical of *reasoning* or *creative imagination.* Let us first give some details concerning the dream.

Uncontrolled Thinking.—Dreaming, in the first place, is thinking, and it may be predominantly reproductive or highly imaginative. Reproductive dreaming would consist in recalling faithfully during sleep the events as they were experienced in the past. This form of dream is probably less usual than the fantastic dream, but mixed dreams, including the recall of real experiences together with more or less novel or absurd material, are frequent. The most striking difference between night dreams and daytime reveries is the convincing reality of the former; it is imagination or recollection mistaken for real experience. During the broodings of the day, consciousness is never so narrow and uninfluenced by sensory perceptions as in the dream. One may imagine he is floating above the housetop or singing to an enthusiastic audience by day, but he is simultaneously aware of visual, auditory, tactile and other impressions that belie the reality of the imaginings. In deep moments of imagination, the tinkle of the door bell, the rustle of a paper, or the odor of smoke may bring one completely to the perceptual present. In dreams, the contact with the external world is largely cut off, consciousness is narrowed to a few ideas and these are unhampered either by the perceptual present or by the subtler mental processes, the critical, discriminative activities and attitudes that in waking hours operate so potently in the background of consciousness. In the dream, consciousness lacks breadth and depth; ideas fol-

low one another by superficial associations rarely guided by any stable aim or purpose, rarely checked up as regards their congruity one with another, or with ordinary standards of reasonableness or probability. The ideas in themselves, not new, are linked together in unusual or absurd ways or appear in bizarre combinations that seem real only because mental activity as a whole is at such a low ebb. Dreams represent, then, the extreme of uncontrolled and uncriticised association of ideas.

The motives effective in dreaming are not unlike those activating ordinary recollection or imaginative reverie. We dream of eating delicious foods, of winning prizes or acclaim, of attaining riches or of satisfying almost any positive desire. We experience dreams of the suffering-hero type also with its typical satisfaction. But in dreams, more than in recollection or daytime imagination, we experience the unpleasant; we dream of great misfortune encountered, of horrifying, terrifying and disgusting things and events. Now the explanation of the frequency of unpleasant dreams, as compared to imaginations and recollections, is precisely the same as the explanation of the illusory reality of the dream. Dreams are less well controlled, less subject to criticism, less easy to start, modify or halt. When the unpleasant recollection of a day dream begins, we switch our attention to something else and substitute a more pleasant line of thought. At night we lack control; a freakish train of thought getting under way commands the whole field of consciousness. We cannot penetrate its unreality; we cannot modify its course; we cannot stop it until we become more wakeful.

Controlled Thinking.—At the opposite extreme of dreaming, in which control by conscious aim or purpose is nearly zero, is highly controlled or selective thinking typical of *reasoning* or *creative imagination.* Between

the extremes are many stages; the confused thinking in the state of drowsiness or intoxication is near the dream state; the state of distraction or "absent mindedness," in which one falls occasionally, is better controlled; ordinary reverie is still more thoroughly controlled; while alert, critical, concentrated activity in solving a problem or in creating a musical composition is highly controlled and selective.

Just as any type of thinking may be classified as predominantly reproductive or predominantly imaginative, any type may also be classified as high or low on the scale of control and selectivity. In the rare dream composed of recollections of real experiences, the thinking is reproductive but uncontrolled and unselective. It cannot be modified or stopped by our conscious efforts; it is quite as realistic as the imaginative dream and quite as unmanageable. Aimless reproductive recall during reverie like imaginative day dreams is much higher on the scale of control. Recall for a definite purpose as during an examination or in solving a practical problem is regulated and selective, but no more so than during effort to conceive (imagine) a new costume design, cartoon, breakfast food, automobile engine, musical composition, or literary form. It is to the characteristics, limitations and possible improvements of the highly controlled forms of selective thinking, whether in reasoning or invention, in practical or in artistic lines, that most of this chapter will be devoted.

Reasoning and Creative Imagination.—Reasoning is the term applied to highly purposeful, controlled, selective thinking, predominantly of the *reproductive* type; creative imagination is the term applied to highly purposeful, controlled, selective thinking of the *imaginative* type. In actual life, the two are very similar so far as

the actual mental activities involved are concerned even when we consider extreme examples of each type. Highly controlled and purposeful thinking, moreover, is rarely exclusively reproductive or imaginative, but shifts from one to the other constantly or lies between the two. For these reasons, it will be inadvisable at the outset to emphasize the distinctions too much. It will be preferable to take up several examples of actual purposeful and controlled thinking, pointing out the similarities and differences that appear. We shall begin with some illustrations of reasoning of the problem-solving type.

Reasoning and Problem Solving.

The Characteristics of Reasoning.—Reasoning is a form of learning as well as a phase of thinking. It is a term applied to types of learning that are at once very subtle and very complex. Reasoning may be contrasted with all types of activity which consist merely in the repetition or recall of reactions previously acquired or in mere random or aimless activity. Typically, reasoning is involved when the individual is confronted by a novel situation or a problem-situation for which his native and acquired modes of reaction do not at once provide a satisfactory solution. The final or consummatory action is delayed and during the delay one must learn what to do. The process of learning what to do by reasoning is not, however, to be sharply distinguished from ordinary forms of trial-and-error learning. The two are similar but the extremes offer important contrasts.

How Animals Solve Mechanical Problems.—Some of the characteristics of reasoning may be observed by comparing the behavior of animals with those of men in problem-situations which embrace comparable features. When a cat is placed in a puzzle box that may be opened

by some simple manipulation of buttons or latches, its activity seems to be mainly motor. It tries to squeeze between the bars, it claws or bites at buttons, wires, strings, and other objects. The activity is usually incessant; there is very little evidence that the animal thinks the problem over—at least, it does not appear to "stop and think." It continues to try all of the forms of manipulation in its equipment, until finally the right move is hit upon, apparently by accident. When the cat is again placed in the box, it gives evidences of little understanding of the solution. It apparently does not know just how the previous escape was brought about. The task of learning the way out a second time is nearly as difficult as before. The solution is gradually acquired by a process of trials, elimination of annoying errors and the selection of the successful and hence satisfying reactions.

How Some Men Solve Mechanical Problems.—The duplication of such an experiment with human subjects may be approximated by using a latch or some sort of mechanical puzzle which will be as new to the man as the puzzle box latch was to the cat. The general features of the learning by man are often very similar to those employed by the animal. The former resorts at once to manipulation, turning the parts this way and that, twisting, pulling, pushing; sometimes repeating the same futile effort time after time—foolishly, one who knew the trick might say—sometimes shifting rapidly without apparent aim, sometimes retracing the old steps. In the course of these varied attempts the solution may be hit upon, often so unexpectedly that it is not understood at all. The second trial may then be much like the first; but at length the useless moves are eliminated while those constituting the solution are retained and perfected. This

example of learning we should be inclined to call a rather stupid human performance in which little, if any, reasoning is involved. It is, nevertheless, a type of human learning that is not unusual when the problem is both novel and difficult.

Reasoning in Solving Mechanical Problems.—Some learners, however, proceed in a different fashion. They manipulate less while observing and thinking more. Holding the puzzle before them, they carefully study its construction, estimate the results of various moves, and keep on the lookout for clues or suggestions. They may also attempt to recall the solutions of other puzzles or to apply general or particular facts learned from preceding experiences with door locks and other mechanical devices. The learner does more than merely manipulate the object; he recalls various facts which careful perception of the puzzle suggests and manipulates or explores among these ideas. There is an active search to link the present problem with past experiences which utilize the same principle. This tendency to utilize recalled facts in addition to those that may be directly perceived in the problem-situation is one of the important characteristics of reasoning.

In reasoning, we have not sidetracked the familiar trial-and-error procedure. We have merely widened the field of manipulation. Not only may we explore among facts presented to the senses, but we may also explore among facts recalled. New facts may be observed not only in the situations present to the sense but in those present to mind. The recall of pertinent facts, general and particular, is an effective way of bringing our past experiences to bear upon our present difficulties. The learner succeeds in recalling *pertinent* facts; in other words, his thinking is controlled and selective. He does not recall unrelated

and bizarre facts as in the dream; his purpose and aim facilitate some facts rather than others, although selectivity is rarely if ever perfect.

The good reasoner not only recalls, but he carefully observes the present situation and his own reactions. The facts observed may be later recalled so that he can rehearse the whole problem mentally, thus saving muscular work and often leading to a solution. Careful observation, too, often enables him to recall the state of affairs which attends an accidental discovery of the solution, thus avoiding the common waste of effort shown by animals that hit upon the solution without having perceived it. The careful observer may recall the circumstances and his own reaction and thus "see" how it happened or at least observe clues whose usefulness appears during the next trial. In this, as in other typical instances of reasoning, thinking is highly active, controlled and selective.

Reasoning in Solving Verbal Problems.—These characteristics may be illustrated by the solution of verbal problems of the type similar to many that we solve in everyday life. It has been found experimentally that the problem below is of the degree of difficulty that taxes the ability of, but can be solved by, an average child of nine years. Be sure to solve the problem before reading the discussion which follows it.

In cold, damp climates, root crops, like potatoes and turnips grow best;
In temperate climates, there are abundant pastures, and oats and barley flourish;
In sub-tropical climates, wheat, olives, and vines flourish;
In tropical climates, date-palms and rice flourish;

The ancient Greeks lived largely on bread, with oil for butter; they had wine to drink and raisins for fruit.

Which climate do you think they had?

To solve this problem, the child must first fix upon the main question, which requires some analysis. Out of the last two statements the "What climate did they have" statement must be combined with the notion of Greeks, so that the question becomes clearly "What climate did the Greeks have?" The solution will not be obtained unless this question is perceived and remembered. Next, information not contained in the problem-situation must be available and it must be suggested by getting the right facts together. The child must know that bread comes from wheat and not from root crops, potatoes, turnips, date-palms, etc. He must know also that oil comes from olives rather than oats, potatoes, rice, etc., and that raisins are to be associated with vines, rather than with date-palms, turnips, etc. These facts—assuming that they are known—must be brought out during a process of study in which many irrelevant matters are observed and discarded. Several erroneous hypotheses may be suggested as various facts are viewed together before the correct solution is obtained by narrowing the field down to the facts contained in lines 3, 5 and 6, and seeing the relations contained therein. In reasoning the solution of a verbal problem, then, we find the analysis of the gross situation into its elements, the supplementation of these minute facts by others recalled from past experience, and the perception of previously unobserved facts in new combinations of details. This last point merits some elaboration.

The Discovery of New Facts during Reasoning.— The result of observing many details and recalling many past experiences is the possibility of reacting to many selected situations operating at once. Solutions are discovered and new ideas or hypotheses conceived by getting together in a single moment of consciousness many aspects

of the present situation and of past situations more or less relevant. Sudden insights into the problem, suddenly "getting a point," seeing into or "seeing through," suddenly conceiving a solution—these are other ways in which the culmination of reasoning is described. Perhaps the best general term with which to express the outcome of reasoning is hypothesis, inasmuch as the "idea" conceived is not always a real solution. It is a possible solution sometimes proving to be correct, sometimes incorrect. In the latter case, the search is continued until other insights or hypotheses are achieved. The solution is an hypothesis which proves satisfactory. In difficult problems, the correct hypothesis may be preceded by many incorrect ones which are eliminated in the process of further study.

An hypothesis is really a conscious response made to several features of the problem-situation and recalled ideas acting at once. While "seeing" many things at once, some facts contained in them or suggested by them come to mind. Such hypotheses and discoveries during the process of thought are much like the perception of a similarity or difference among several things observed at once. Indeed, such insights are a kind of perception, except that they may occur when the facts are not present to the sense but are only thought of or when perceived and recalled facts are combined. Many discoveries are made during reasoning because so many facts apparently remote and unrelated may be brought together in thought that could not be brought together as things or events in the actual world. Human ability to represent facts previously experienced thus broadens greatly the opportunity to learn. This ability is, of course, the fundamental prerequisite to reasoning.

Recall is essential to reasoning, but reasoning at its

best is more than mere recall; it is the "seeing" of new facts in those recalled or in the facts recalled combined with those perceived. It is the apprehension of facts not previously noted. Whether this result is called a percept, hypothesis, inference, insight or discovery matters little. The suddenness with which it appears, though a long period of exploration may have preceded it, is frequently characteristic. It seems virtually to "pop out." Facts which amount to great discoveries are often finally "seen" with equal suddenness. To illustrate: "Hauy drops a bit of crystallized calcium spar, and looking at one of the broken prisms, cries out, 'All is found!' and immediately verifies his quick intuition in regard to the nature of crystallization." [1]

The world is full of facts awaiting someone sagacious enough to see them. The person who perceives them first makes a discovery and is quite properly accredited with genius. Others see them readily enough when they know what to look for and how to look. This point is well illustrated by a story from the life of Darwin, in which he describes his observations of some natural phenomenon after Agassiz's discovery of evidence of a glacial period in prehistoric days. "We spent many hours in Cwm Idwal, examining all the rocks with supreme care, as Sedgwick (another eminent scientist) was anxious to find fossils in them; but neither of us saw a trace of the wonderful glacial phenomena all about us; we did not notice the plainly scarred rocks, the perched boulders. . . . Yet the phenomena are so conspicuous that . . . a house burnt down by fire did not tell its story more plainly than did this valley." [2]

[1] Ribot, *Essay on Creative Imagination*, p. 247.
[2] *Life and Letters of Charles Darwin*, quoted from Sellars.

Types of Reasoning.

The mental operations which comprise reasoning are essentially the same in the many varieties of problems that are encountered. Any situation which is at once novel and complex, whether in practical affairs, school subjects, religion, æsthetics, music, or any other field, provides the occasion for reasoning. In addition to the problem-situation, there must be a motive. And the variety of motives is wide. We may reason just for the satisfaction in mastering a problem, although frequently the incentive is the desire to secure some end—food, comfort, a fact needed in business—or to avoid some annoyance, such as confinement, deprivation, or thwarting. No convenient categories seem to include all varieties of motives nor of problem-situations, but the following groups suggest types that are distinctive with respect to the general methods of procedure.

1. Finding the Key to a Complex Situation.—Most of the practical problems fall under this head. Typically, the individual is confronted by a complex situation, which offers a large number of possible reactions. The question is to find the one satisfactory response, that is, the solution, as when we encounter situations and ask such questions as "What is this?" or "What is this for?" "How is it used?" "What does this mean?" "Where can my umbrella be?" "How did this get here?" or "How did you do that trick?" In all of these cases the number of interpretations is legion. We must take them up one after another, try them out, reject useless clues, follow up promising lines, supplement them by recalling past experiences and trust to getting together eventually the combination of details which will suggest the answer to our question. The solution of mechanical puzzles, the

search for the cause of the balking of an automobile or for the main point in a poem are of the same type. The essential characteristic of this type of reasoning is the presence of a large number of facts or details among which we find a satisfactory response.

In the foregoing illustrations the solution was typically some concrete line of action or the perception of some particular fact which was the key to the situation. The so-called inductive reasoning so abundantly utilized in science is essentially the same, except that the key is usually a general rather than a particular fact. Science aims to discover laws, or general explanations. Thus Darwin, after observing a large number of variations among animals of the same species, and similarities among different species which amounted to an essential continuity, finally conceived a single explanation for all of these facts, namely, the theory of evolution. This theory was really a key to the complex situations, in much the same sense that after puzzling for a time with an arithmetic problem a child sees that the thing to do is first to add certain figures, and then subtract another figure from the sum. As a psychological process it makes little difference whether the solution is a great law or a particular fact.

2. **Application and Verification.**—Reasoning may take its start from a general principle and seek for particular cases which illustrate it. One may attempt to apply a general law, either for the purpose of observing whether it holds good or not or for the purpose of understanding it better by practice in using it. If the interest is in testing the validity of a general statement, the process is called *verification*. If one does not question the generalization but wishes to find new particulars which it covers, the term *application* is frequently used. In either case

the general fact becomes one element in the situation which must be grasped and held in mind while various concrete situations, perceived or thought of, are viewed with it. Getting the general and particular facts together, it is necessary to perceive their essential similarities or differences; to see whether they fit or are unrelated. Of course, there must be a great deal of exploration, trial-and-error activity, in recalling particular cases and trying them out. This form of thinking, of which there are several varieties, is called *deductive reasoning* in contrast to the *inductive method,* but both are essentially the same psychologically. Both imply a novel and complex situation, a search for clues, the recall of facts and experiences, and the thinking of several things at once.

In many instances, both the inductive and deductive procedures are employed. In trying to figure out the use of a new piece of apparatus, a person may be led from the study of particular parts to an hypothesis concerning the whole and then attempt to verify the hypothesis by applying it to the concrete situations which the theory suggests. In scientific investigations a general law, such as the Law of Effect, which is arrived at after long study of particular events, is later tested by trying it out in new situations in which it should hold and it is finally applied broadly to meet practical needs. On a smaller scale, laboratory experiments may include the same steps: discovery of the "key" or general law, then its verification and application.

Criticism and Discrimination.—In criticism and discrimination, which in some form is perhaps the most customary type of human reasoning, both the inductive and deductive features are apparent. In buying a hat, the purchaser usually becomes critical. She begins by analysis of the features of the hat, its predominant color,

the color combination, the trimming, the quality of the materials, the size, shape and style. Not only may these features be viewed singly, but they must be viewed together tc ascertain the general effects. Not only will there be search to perceive the character of the details and the general effect, but there will be considerations of these in the light of certain general ideas; there will be an application of principles. For example, she must be in style; therefore, she recalls the prevailing fashion and proceeds to observe the hat in the light of it. Is this hat a particular case of the accepted style? This question is really identical with that of the man of science when he inquired: "Is this a particular event covered by the Law of Effect?" The same is true of the buyer's appraisal of the hat from the point of view of its appropriate price, or its fitness for her purpose, such as afternoon wear; or its harmony with the rest of her costume or her figure or complexion. Criticism of and discrimination among hats is, psychologically, no different from the work of the literary or musical critic, or from the evaluations in the moral, mechanical, legal, æsthetic or any other field of conscious activity. Criticism then is like other types of reasoning that have been or might be mentioned in the fact that it involves a problem-situation, the analysis of the whole into its details, the recall of related facts, general or particular, and the reaction to many things at once. Let us now take up creative imagination to ascertain in what respects, if any, it differs from reasoning.

Creative Imagination.

The reasoning involved in criticism affords about the sharpest contrast, in certain respects, with creative imagination that may be found. Compare the music critic and composer. The music critic must be able to reason;

to analyze a composition, to classify and evaluate its elements in accordance with recognized norms of good usage, to see the similarities to, and differences from, other compositions, good and poor. Superficially, this type of thinking seems to be very different from that involved in creating a composition. The composer must imagine new things, not merely react to what is before him. To be sure, he utilizes recalled facts and must work, in his imagination, with musical notes. His work, however, is that of imagining new combinations of these notes; he must create. Perhaps many melodies come to him only to be discarded. They are discarded, however, in the light of some standard; because they fail to suit his purpose which may be to secure a new combination of a prescribed type. Really, the new combinations which occur to him are psychologically much like the "trials" of the person trying to solve a difficult mechanical puzzle or the insights of the mathematician working on a difficult problem, or the hypotheses of a scientist searching for a general explanation of the movements of clouds or stars. The trial movements or insights or hypotheses are really new combinations of simpler movements, operations or ideas, respectively, just as the tentative melody is a new combination of strains or notes. In all of these cases, moreover, the trial product must be evaluated in the light of other facts, rules, laws or standards of some sort. The test of the manipulative response is simply whether it unlocks the puzzle; the test of the mathematician's insight is whether it produces the right answer; the test of the scientist's hypothesis is less precise and final, but it must explain all of the facts, must explain them in the simplest way and must be consistent with explanations in related fields. The test of the musical composition is still less rigid and conclusive, but it must

observe certain accepted standards of harmony, rhythm and originality. In this respect it is much like the choice of a hat; the one chosen must obey certain general requirements, but many different hats might do so quite satisfactorily. Thus the distinctions between types of reasoning and creative imagination are not so clear as they may appear at first sight. They are practical rather than psychological. The field of purposive, controlled, selective thinking is as broad as the world of facts that may be perceived or imagined but the characteristics of purposive thinking are very much alike whatever the purpose, the kind of facts utilized, the character of the products or the nature of the tests of validity applied.

The Improvement of Methods of Reasoning and Imagining.

With the characteristics of reasoning and creative imagination now before us, we may undertake a discussion of the equipment essential to good selective thinking, the methods by which and the extent to which it may be improved.

The Need of Facts.—Successful reasoning and imagination depends upon an abundance of ideas, particular and general facts and principles. In reasoning, we pick and choose among facts, view this and that together. Few people are able to reason about the Theory of Relativity, Evolution, or Electro-therapy because of a lack of the essential stock of facts. And some who could reason well concerning the explanation, application, or verification of these theories, might reason very poorly about a balking automobile, investment securities or pains in the chest, because of lack of information concerning mechanics, finance or the diagnosis of disease. Unless the person has had previous experience with a situation in

some degree similar, unless he has dealt with material of the same sort before, he may be quite incapable of finding a solution except by accident. An eminent thinker once compared the situation during reasoning to two chambers, a main chamber in which manipulation and study were going on, or in which the leading ideas were being rehearsed and an antechamber crowded with ideas seeking an entrance to the main room. Unless the antechamber were well filled little could be done. The most hopeful sign of probable success was an anteroom teeming with candidates for a "trial." If we are to become competent thinkers in any line, the first, and by all odds the most important thing is to accumulate experience and master the facts in the field. Without the facts and experience, the most gifted mind would be helpless. The most productive thinkers are not those who disregard the knowledge, methods, trials and errors of others, but those who are most familiar with them. Originality or creative imagination is not opposed to the amassing of facts or the laws of ordinary learning, but dependent upon them.

Originality in Art.—In thinking in the fields of literary, musical and other artistic productions, familiarity with the products and techniques of the masters seems to be quite as useful as acquaintance with the facts is essential to originality in other fields. In the æsthetic fields the fear that familiarity with other products may cramp or inhibit originality seems to be more frequently and tenaciously held than in business, mechanics or science, but for no good reason. In the better types of instruction in composition, drawing, design and the like more attention is given than formerly to study of good products, to theory and technique. Originality is fed by such equipment; starved by poverty of examples and precedents.

Keeping the Problem in Mind.—Given an abundance

of information with which to work, the first step in solving a problem is to understand thoroughly and remember the question or problem set up.

The problem held clearly in mind acts as a selective agency during the activities of reasoning. It tends to favor the perception of the facts appropriate to the solution of the problem. The successful thinker finds that out of the variety of possible meanings which each detail may yield, the right ones appear. Others find that the right suggestion will not come. Tell a subtle joke to any group of people; some will see the point at once, but to others it comes slowly or not at all. When the right idea does not come, one is not left altogether helpless. One should not passively wait for something to come. Success may be achieved by instigating certain maneuvers.

A Systematic Analysis of Details.—The first maneuver is to proceed with the main question in mind and to examine actively the problem in piecemeal. Focus attention on one detail. Significant matters overlooked when the problem is thought of as a whole may be detected during an active study of one phase after another. In teaching, the habit of analytic scrutiny may be encouraged by questions directed to parts of the problem. Systematic procedure in which details are taken up in orderly fashion, their relation to the problem ascertained and futile leads noted, should be cultivated by means of practice under guidance.

One trait, antagonistic to successful reasoning, is inflexibility. In attempting to solve a mechanical puzzle, a subject observed (by Ruger) spent ten hours on one line of attack. After having stated his assumption, which was an erroneous one, the subject was requested to strike out along other lines. Aften an hour and a quarter, he was asked again to tell what he was doing. He was still work-

ing on the same futile clue! This kind of stubbornness or inflexibility is a fatal obstruction in the pathway of reason, and is reminiscent of the logic-tight compartments mentioned in Chapter IX. Originality, fertility and efficiency in thinking depend, in some degree, upon habits of openmindedness, of keeping alive to a wide variety of stimuli and of remaining sensitive to all of the suggestions that a situation may contain rather than in thinking only along the line most readily suggested.

Some subjects show a tendency to skip about among the details of a problem in a superficial fashion, which is quite as serious a fault as too great a tenacity in sticking to a few clues. A promising line is undertaken and followed up for a while, only to be suddenly dropped as another suggestion occurs. This kind of learner is too readily distracted; he is continually getting very "warm" but by hastiness is robbed of a victory almost within his grasp. A similar defect in thinking is the superficial impulsive acceptance of any conclusion which comes to mind, obvious among most children and many adults. There seems to be a native disposition to accept as reliable any idea that comes easily. While guessing is to be encouraged and while it is in general advisable to entertain suggestions that thinking produces, it is quite as desirable to establish habits of maintaining a state of doubt, of being critical and of testing suggestions before they are accepted.

"Scatter-brain" and impulsive thinking and inflexibility may to some extent be remedied by cultivating the habit of systematic procedure coupled with efforts to formulate articulate hypotheses concerning the solution. Teachers may assist by asking the pupil, "What is your problem?" "What facts are you now considering?" "What do you think is a possible solution?" The learner

should work, not aimlessly waiting for things to happen, but with a definite question or assumption in mind. Each assumption should be tested until its worth is determined beyond a reasonable doubt, then dropped and another taken up, until one by one the possibilities are exhausted. Such a procedure tends, for one thing, to narrow the field of operations. If the solution does not show itself spontaneously, it may be finally cornered and thus captured. Changes in the assumptions widen the possibilities for suggestions since the same details may be perceived differently as words may have different meanings when the point of view is changed. Solutions coming as the answer to the question or in the course of the testing of a hypothesis are better understood than those which "just come." If the solution is anticipated and linked with an assumption it is better observed and comprehended. Usually an assumption grows out of past experience which is formulated as a general rule or principle. The present solution is then perceived as a case which fits into a familiar type.

Generalization.—The subject, then, should study details in connection with the main problem, attempt to guess the solution as he goes along, give each guess a fair tryout and advance systematically. When the problem is solved it is advisable frequently to review some of the steps in an effort to generalize or get the principle of the problem. The value of generalization was shown very clearly in the studies of mechanical puzzles, as indicated in the following quotation from Ruger: "A certain puzzle was so arranged that it could be presented in various forms. The manipulation for these various forms could all be comprised under a single formula. This general formula could be deduced from any one of these special forms. A number of subjects were tried with the puzzle.

As soon as skill was acquired in dealing with one form of the puzzle it was changed to another form. The subjects who developed the general formula during the solution of the first form were able to use in the second form the specialized habits built up in the first form. Those who formed merely the special habits without developing the principle attempted to carry over the habits without modification and were greatly embarrassed by the change." The good thinker not only solves his problems but explains the solution in terms of some general formula or principle.

The suggestions thus far made concerning methods of improving reasoning are drawn from experimental studies of children and adults in solving various types of problems. There are two other sources of suggestions concerning methods of thinking: the facts of logic and the reported experiences of great thinkers. Let us see what may be learned from these sources.

The Study of Logic.—Logic is the study of the outlines of representative forms of reasoning. Logic is not much concerned with the processes of reasoning, that is, the difficulties of keeping the problem in mind, the futile moves, etc. It is concerned with the validity of the results reached—whether the solution is justified or not. Logic is related to reasoning in much the same way that grammar is related to composition. The study of grammar will do little to develop skill or style in writing, but it will assist in the task of detecting correct and incorrect usages and enable the learner to repeat the former and avoid the latter. Similarly, logic may assist in indicating forms of thought that are valid and invalid.

In logic, samples of reasoning are analyzed into their elements, which are usually displayed in a simple graph, diagram or short series of sentences. These summaries

make more apparent various fallacies that were obscure when expressed in cumbersome or expansive verbal form. The various correct and incorrect forms of reasoning may also be classified in several types. Once an effective classification is made, reference and interpretation may be facilitated.

Properly utilized, knowledge of logic—especially of the common fallacies in thought—may be of some value in developing more valid and rigorous habits. But like rules in grammar, principles of logic may be learned quite independently of the activities they are supposed to assist. They may be memorized but insufficiently applied. To be effective, they must be introduced during concrete experiences. They must be illustrated by and fused with the activities of reasoning.

The Study of Methods Used by Great Thinkers.—Men and women of eminence in fields of reasoning, creative imagination and invention sometimes undertake to describe the general methods used or the detailed steps found in some phase of their work. Such accounts differ widely both in validity and suggestiveness. In the main, great thinkers, composers, artists, inventors really do not know how their results are achieved in anything approaching detail. As in reading or singing, playing the violin, perceiving distance or traits of character, it is one thing to be a good performer and quite another to know how the ability was acquired or how the performance now goes on. One rarely knows. The usual accounts, therefore, are more likely to be rationalization than genuine observations, comparable with the familiar magazine accounts of "How I Lived to Be a Hundred Years Old." They are likely to be full of erroneous ideas and lacking at the really vital points. Indeed, the happenings at the vital moments of reasoning or imaginative thinking are

so complex and subtle that they scarcely permit analysis.

The Need of Practice under Guidance.—Learning to think, reason, or imagine creatively is, after all, similar to the task of learning to whistle, read or pitch in baseball. General directions of value may be given, the gross features of good and bad procedure may be portrayed or explained, something can be learned by observing the work of others directly or as reported, but there remains a vast number of subtle techniques, devices, "tricks of the trade," that are very difficult to identify. The proficient performer does not appreciate them himself. They differ greatly, moreover, from person to person. These unanalyzable techniques, unfortunately for the learner, are likely to be of extreme importance. The only way to secure them is through abundant practice, especially practice carefully observed by an expert teacher or carefully studied by the learner himself, or both. Just as we learn to sing only by singing, we learn to think by thinking, and we learn to create by creating. And just as we may "practice errors" in singing, we are likely to establish bad habits of solving problems, sifting data or producing literary compositions. In learning to think as in other types of learning, abundant practice carefully checked up is the most productive source of improvement.

QUESTIONS AND EXERCISES

1. During recall of the following situations or facts, note and later describe the conscious processes found: the feeling of velvet; the taste of vinegar; the sight of a red rose; the sound of a horn; the sentence "All men are mortal"; the idea, liberty, hardness, if, triangle. Do you ever recall a fact without images of any sort?
2. Describe the two types of scales upon each of which, according to the text, any type of thinking may be allocated. Recall sev-

eral instances of thinking, to see whether other characteristics are left unaccounted for.

3. The following problems are of such difficulty that approximately one-half of the children of the given age succeed in solving them and one-half fail. (From Cyril Burt, *Mental and Scholastic Tests*, London: P. S. King & Co., 1921, p. 356 ff.) Solve these problems and describe the mental operations involved.

8 Years

All wall-flowers have four petals: this flower has three petals. Is this a wall-flower?

10 Years

There are four roads here. I have come from the south and want to go to Melton. The road to the right leads somewhere else; straight ahead it leads only to a farm. In which direction is Melton—north, south, east, or west?

12 Years

Field-mice devour the honey stored by the bumble-bees: the honey which they store is the chief food of the bumble-bees. Near towns there are far more cats than in the open country. Cats kill all kinds of mice. Where, then, do you think there are most bumble-bees—near towns, or in the open country.

14 Years

John said: "I heard my bedroom clock strike yesterday, ten minutes before the first gun was fired. I did not count the strokes but I am sure it struck more than once, and I think it struck an odd number." John was out all the morning, and his clock stopped at five to five the same afternoon. When do you think the first gun was fired?

4. Typewrite the problems and try them on children of different ages. See if you can ascertain the good and bad features of their methods of reasoning.
5. Do you think such a list of problems really provides a measure for general ability to reason? For which of the following fields of reasoning would it probably be the best test—law, medicine, mechanics, business, music, science, history, art, philosophy, economics? For which the poorest?

6. Do you think that training in logic or scientific methods would increase efficiency in solving such problems? Would training in arithmetic? Grammar? Geometry? Algebra?
7. If you were to extend this list to make a better test of ability to reason, what kinds of *content* would you prefer?
8. Buy a few mechanical puzzles from some toy store. Carefully examine your procedure during solution. See if you can apply any of the suggestions given in the chapter. Try the same puzzles on friends, both children and adults. Record the time required to solve the puzzle. Put the puzzle together and have them try it again and repeat until they reach a physiological limit. Compare the methods of children and adults with references to care in observation, the search for general principles, the recall of previous experiences, the formation and use of hypothesis, the understanding of the solution, etc.
9. See what you can do by way of explanation and illustration to improve the methods of attack used by others.
10. Invention. The ordinary tooth-paste tube is unattractive, unhygienic and clumsy. Think of some attractive mechanism—if possible, a more permanent bathroom fixture—that will remedy these defects. While doing so compare the mental operations with those observed in solving the verbal or mechanical puzzles. What are the similarities and differences? Is this type of invention reasoning or creative imagination? Justify your answer.
11. Artistic creation. The ordinary collar and tie which men persist in wearing, is not comfortable, not especially attractive, and desperately troublesome to get on and off. Imagine and, if possible, sketch a new neck-gear that is more attractive and comfortable and also practicable. Compare the mental operations with those above. Is this a sample of reasoning, imagination or what? Compare it as a type of thinking with the creation of a new dress or wallpaper design or a new melody.
12 Try to locate in an autobiography or magazine article or elsewhere, some eminent thinker's account of how he solved some particular problem or made some invention. Examine the report critically, especially those in which advice is given, to observe what really useful suggestions are presented.
13. Do animals reason? Before giving your final opinion, read over the sub-headings of Chapter I.

14. What facts presented in Chapters I and X bear upon the study of reasoning?
15. Does the average farmer, chauffeur, stenographer, salesman, cobbler, housewife, physician, or banker reason very much? After several years of experience in any of these vocations, is it more or less *necessary* to reason in order to get along efficiently than at the beginning? After several years is one more or less *able* to reason in that field?
16. How often do you reason when it is not necessary or "for the fun of it"? Just what *is* "the fun" of it? Has it an instinctive basis?
17. Criticise or defend these statements: "Necessity is not the mother of invention. Knowledge of previous inventions is the mother; original ability is the father." (From E. L. Thorndike. *The Psychology of Arithmetic,* p. 278.)
18. State your opinion on these assertions: (a) We require in general too much learning by rote in our schools and colleges; (b) If we clutter the child's mind with memorized facts we interfere with his thinking; (c) It is not that too much is memorized, but rather too little; (d) It is not that too much is memorized, but that unessential material is learned; (e) Not too much memorization, but memorization in ineffective ways.
19. Of the various suggestions offered for the improvement of reasoning, which do you consider most important? Which least important? Why?
20. Which is more likely to stimulate a high-school boy to think,—the study of formal logic or a serial detective story? Will either improve ability to reason in general? What material would be better than either?
21. If you were trying to encourage students to attempt to think, to invent, create, solve problems—would you choose tasks very easy or very hard or moderately hard. Why? Compare with your choice of opponents in wrestling, tennis, etc. Is there any basis of comparison here? If so, what?

GENERAL REFERENCES

A statement of recalled facts in terms of images will be found in E. B. Titchener's, *Textbook of Psychology,* New York: Macmillan, 1914. A survey of several theories concerning the nature of meanings

is given by W. McDougall in his *Outlines of Psychology,* New York: Scribner's, 1923, Chapter 8. Different accounts of meaning in terms of sequences of mental processes appear in W. S. Hunter, *General Psychology,* Univ. of Chicago Press, 1919, Chaps. 8 and 10, and H. L. Hollingworth, "Particular Features of Meaning," *Psychological Review,* Sept., 1924. An excellent discussion of imageless processes is given by M. F. Washburn in *Movement and Mental Imagery,* Boston: Houghton Mifflin, 1916, Chap. 10.

More general treatments of the topics discussed in the chapter will be found in the following:

William James, *Principles of Psychology,* New York: Henry Holt, 1890, Vol. II, pp. 325-371.

John Dewey, *How We Think,* New York: D. C. Heath, 1910.

W. B. Pillsbury, *The Psychology of Reasoning,* New York: D. Appleton & Co., 1910.

F. W. Taussig, *Inventors and Money-Makers,* New York: Macmillan Co., 1915.

R. S. Woodworth, *Psychology,* New York: Henry Holt, 1921, Chapters 18 and 19.

Columbia Associates in Philosophy, *An Introduction to Reflective Thinking,* Boston: Houghton Mifflin, 1923.

H. A. Ruger, *The Psychology of Efficiency,* New York: Teachers College Bureau of Publ., 1910.

CHAPTER XV

MENTAL ORGANIZATION AND THE TRANSFER OF TRAINING

Under the terms attention, perception, memory, reasoning, imagination, a number of facts concerning human behavior and the processes of learning have been presented in preceding chapters. There remains, however, the need of surveying more critically the nature of these functions, their relations to each other and the influence of training upon them.

THEORIES CONCERNING MENTAL PROCESSES.

The Theory of Mental Faculties.—There are many theories concerning the nature of such processes as perception and memory, and the character of their interrelations. We shall be able to consider only the two main types of theories, giving no details concerning the several particular hypotheses of each type. One theory, old in the history of philosophy and science and now highly popular in other circles, is the *theory of mental faculties*. According to this theory attention, memory, perception, reason, imagination, and sometimes others such as the will, judgment, and discrimination are powers or faculties of the mind. Usually the faculties are held to be mainly if not wholly independent of each other. The mind is the sum of the actions of the several faculties. The faculty is a general power or capacity, moreover, which operates indiscriminately in all lines and on all kinds of material.

Individuals are assumed to have good, medium, or bad memories, judgments or wills; it is implied that these traits are about equally good or bad in all situations. Memory, to be concrete, is the power of acquiring facts. If you have a good memory everything is easily learned; if your memory is bad, all facts are acquired with difficulty. Those who held this view usually made the assumption that the various faculties could be improved by training. And when this opinion was held, it was necessary to make the further assumption that the faculty or power is trained as a whole. If memory was improved by training of one sort or on some one material, it would be improved for work on other kinds of data and in other situations.

If a psychologist were devoted to this view his procedure in diagnosis of a student's difficulties, for example, would consist of a survey of the several faculties. The trouble might be in attention, perception, memory, will, reasoning, imagination, or some other power, or in several of these. Having found the deficient faculty prescriptions for special training of that faculty would be given. Various subjects or systems of training have always been suggested for improving each faculty. For example, educational authorities less than 25 years ago offered special school subjects as a means of improving certain faculties. These quotations indicate the prevalent point of view. Study of German "trains the reason, the powers of observation, comparison and synthesis." "The pursuit of mathematics gives command of attention" and results in "the strengthening and training of the reasoning powers." "Will-power and attention are educated by physical training. When developed by any special act, they are developed for all acts." There have always been individuals, moreover, who believed that courses of train-

ing utilizing materials of a special sort different from the regular academic subjects would be even more effective as a means of developing the faculties. Such systems for training memory, concentration, will-power, and the like are now widely advertised.

The Theory of Mental Functions.—Opposed to the faculty theory is the view that the organism deals primarily as a whole with each of the innumerable situations, problems, and classes of data that it encounters. In this view, attention, memory, perception, reasoning, etc., are conceived merely as aspects of the whole process of dealing with a particular situation. Attention, perception, etc., do not refer to powers or faculties but rather they are to be thought of as abstractions, that is, not as real entities which can exist alone but merely as integral phases of a larger process, namely, the adjustment of the whole organism. According to this view, learning is reacting in a complex way to some situation or data. What one learns is to react to or deal with particular data. Training, then, will not necessarily result in general improvement of attention, memory, or any other power, but in improved adjustment to some situation or in increased ability to deal in some given way with one type of data. If there is a transfer of improvement from one type of work, or from one situation, to others, it must be due to the presence of some common or identical elements among the several types of work or situations. This view may be called the *Theory of Mental Functions*.

How shall we decide between these two general views? One way would be to take up representative samples of human activities and analyze them into their elements; to take perception, for example, and see whether it is really distinct and independent of other "faculties" such as attention or memory. Another way would be to test

the theory by conducting experimental studies of the amount and nature of the transfer of training. Fortunately a very large amount of experimental work of this sort has been done. Let us first indicate the trend of findings from these investigations and later return to a discussion of the theories.

Experimental Studies of the Transfer of Training.

Transfer of Training in Memory.—William James in 1890 was the first to attack the problem of memory training experimentally. James and four of his students each ascertained the time required to memorize material from one author, such as a section of Victor Hugo's *Satyr*, and then after spending about 20 minutes per day for a month or more learning material from another author, they again memorized passages from the *Satyr*. Three of the four students showed improvement while the other student and James himself found no transfer. These experiments were really too crude to be conclusive but they are of historical significance since they stimulated further experimental studies by methods more refined.

A later experiment gave more clearcut results. Students were first tested in learning one kind of material and then, after an average of about 20 minutes' practice per day for an average of 20 days on another kind of material were given a test on the same kind of material as originally learned. The improvements in memorizing the material specially practiced and in the material memorized but once before and again after the practice period are given in the table on the following page.

The table disclosed a marked improvement in ability to memorize the kind of material practiced. The total time of practice was not great—from six to seven hours—and no special instructions, guidance or economical proce-

COMPARISON OF ABILITY BEFORE AND ABILITY AFTER PRACTICE
(From W. F. Dearborn)

	Improvement of Ability Specially Trained		*Improvement in Ability in Memorizing Material Tested Before and After Training*	
SUBJECT	MATERIAL MEMORIZED	PERCENTAGE OF GAIN	MATERIAL USED IN TESTS	PERCENTAGE OF GAIN
1	French vocabularies.....	57	French verse..............	25
3	French vocabularies.....	53	English verse..............	17
4	French vocabularies.....	55	English verse..............	7
6	German vocabularies....	57	German verse..............	25
7	Victor Hugo............	82	Browning	52
8	Horace's Odes..........	73	Norse poems..............	17
9	Paradise Lost...........	68	Chemical formulæ..........	0

dures were suggested, yet by mere practice alone the time required to learn a given amount is reduced at least 50 per cent; in one case by 82 per cent. The improvement transferred to memorizing another type of material was relatively small. Methods of memorizing Victor Hugo's writings are not identical with methods of memorizing Browning; learning to memorize French vocabularies helps somewhat to memorize French verse but helps very little to memorize English verse; learning better to memorize Paradise Lost helps not at all to memorize chemical formulae. In these results it does not appear that memory is a faculty that operates indiscriminately on all kinds of materials or a power that may be trained in general by exercise on any kind of material.

In one respect the experiment just mentioned is unsatisfactory. So rapidly do people often increase in ability to learn by specific practice that in a second test they are usually better than in the first. Part of the improvement attributed to transfer in this study—as the investigator himself pointed out—is really due to specific practice during the two tests, the one before and one after practice on the different material. It is probable there-

fore that the transfer is less than here indicated and in some instances it may be actually a loss rather than a small or zero gain.

A better experimental technique consists in using what is called a "control" individual or group of individuals by means of whom the gains due to practice during the preliminary and final "transfer" test may be measured and subtracted. This procedure is illustrated in the following study: A group of women students were divided into four sub-groups. Group 1, a "control" group receiving no special training; Group 2 learned from 30 to 60 lines of poetry daily (30 minutes a day for 12 days); Group 3 memorized tables, such as population data, export and import tables, and foreign coinage systems 30 minutes a day for 12 days; Group 4 spent 30 minutes a day for 12 days attempting to learn the substance of scientific, historical or narrative prose selections read to them. Just before and just after the practice series, the abilities of all four groups were measured in the following kinds of learning:

1. Learning series of names and dates given orally.
2. Learning series of non-sense syllables given orally.
3. Memorizing pieces of poetry, read by the experimenter and repeated by the subjects.
4. Memorizing prose, as in (3) verbatim.
5. Getting the substance of a prose selection presented orally.
6. Memorizing a series of 9 letters read but once.

By comparing the improvement of each of the *practice groups* in each function with that of the *control group*, the transfer of training was measured. The results, briefly, were as follows: Each group gained rapidly in the kind of learning specifically practiced. The influence

of training in one type of learning on other types was sometimes favorable, sometimes unfavorable. Practice in memorizing poetry produced some improvement in learning tables, non-sense, and prose literally, but a *loss* in ability to learn prose substance or recall letters. Those who practiced learning tables were more able to learn tables, prose substance and non-sense, but less able to learn poetry, prose verbatim and recall letters. Practice in getting the substance of prose had a bad effect upon all other forms of memorizing save the "immediate" memory for series of 9 letters. Transfer may be positive or it may be negative. Practice in one kind of learning may facilitate or it may inhibit other kinds of learning within the same general field.

Other investigations of the effects of the training of memory for one kind of material have shown a transfer of improvement to memorizing other kinds of material that is seldom great, usually between 5 and 15 per cent. Often it is less than 5 per cent and occasionally zero or negative.

The Transfer of Training in Perception.—One of the earliest experiments on transfer in the field of perception was performed in 1903 (by Thorndike and Woodworth). They found that subjects who had practiced estimating the areas of rectangles of certain sizes (10 to 100 square centimeters) until large improvement had been attained, showed only about a third as great improvement when slightly larger rectangles (150 to 300 square centimeters) were given or when the areas were kept constant but the shapes changed. These investigators also found that a period of training which brought about considerable improvement in judging the lengths of lines from one-half to one and one-half inches in length yielded no increase in ability to estimate lines from six to twelve inches long.

It was found that individuals who by practice had markedly increased their ability to pick out words containing the letters *e* and *s* showed less than one-third as much improvement in marking words containing *i* and *t*, *s* and *p*, *c* and *a*, *a* and *n*, or *l* and *o*. Training in perceiving English verbs gave a reduction in time of 21 per cent, but when the same subjects were tested in perceiving other parts of speech they showed a reduction in time of but 3 per cent and an *increase* in omissions of more than 100 per cent. Another investigator (Kline) gave nine individuals practice in canceling *c's* and *t's* from 30 to 45 minutes a day for 14 days. Before and after the practice, the subjects were tested in cancelling nouns, verbs, prepositions, pronouns, and adverbs. Eight other individuals, who served as a control group, were given the same initial and final tests, but received no practice in cancelling *c's* and *t's*. On the final tests the practice group showed less ability in cancelling nouns, verbs, etc., than the control group. Apparently, practice in cancelling letters may cause not an improvement but a decrease in ability to cancel words of certain types.

The Transfer of Training in Reasoning.—An experiment (by Briggs) was designed to test the hypothesis that reasoning, trained in one field, would be improved for work in other fields. The study was designed specifically to test the view, very widely accepted at one time, that rigid training in reasoning in formal grammar would increase in other fields the abilities—

1. To test reasons.
2. (a) To take from a mass of data all that are necessary and to use them in reaching a conclusion.
   (b) To demand all necessary data before drawing a conclusion.

3. To reason syllogistically.
4. To detect "catches."
5. To see likenesses and differences.
6. To test critically definitions of all sorts.

Fifty-four tests were devised to measure, in some form, each of these and certain similar abilities. They were given to children in each grade from 2 to 7 in an elementary school. Each class was then divided into two divisions. Division I, three times a week for three months was taught formal grammar, while Division II worked on composition and language. At the end of the three months' period, both divisions were given a series of tests similar to the first series. After these tests Division II was taught grammar for three months while Division I studied composition and language. At the end of this period the first series of tests was again given to all. Two comparisons of a group studying grammar with a non-grammar group were thus secured. Moreover, the gain in the general ability in each group during the three months of grammar study may be compared with the gain made by the same group during the three months during which no grammar was studied.

This investigation showed improvement in the abilities to deal with the subject matter of grammar but very little transfer of abilities to other situations. On the whole, the influence of the training on reasoning, seeing likenesses and differences, testing definiteness, seeing "catches," etc., in other fields was scarcely perceptible.

Conclusions.—The many studies of transfer, of which we have given but a sampling, indicate in general the following facts:

1. The effect of training in one type of memory or perception or reasoning is usually a marked increase in the *specific function* trained.

2. A relatively small improvement in memorizing, etc., when the form of learning or the material learned is different, even if only slightly different.
3. Complete absence of transfer and negative transfer —that is, a loss of efficiency in one function due to improvement in another—occasionally.

Taken together, the results of experimental studies on the transfer of training are rather antagonistic to the faculty theory. The facts of transfer cannot be explained as general all-round improvement of mental powers such as memory, perception or reasoning for the reason that the improvement is not uniform.

The Factors Which Transfer from One Situation to Others.

The effects of training in one situation do manifestly often transfer to others. The effects which transfer sometimes increase and at other times decrease efficiency in the new situation. The nature of transfer cannot be accounted for in terms of improved faculties but it must be explained in some way. The proper explanation may appear in a study of the character of factors which do transfer, and in surveying these factors the inadequacy of the faculty doctrine will appear more clearly.

The Transfer of Methods of Reacting.—During practice in memorizing, for example, a subject may learn a variety of *methods of attack* upon the particular subject matter, as lists of 12 non-sense syllables. He may learn to use a rhythm such as —′◡ | —′◡ which is often a useful device. When he changes to the study of lists of words, the general problem, 12 items in a list to learn, may call into use the rhythmic division of the items. In this case, the use of the same rhythm probably would be

useful but it might be a disadvantage in learning prose or poetry which has a different rhythm. Again, the subject may hit upon the device of learning by the whole rather than the part method, and this may be carried over. He may find that searching for peculiar syllables to serve as landmarks is profitable and this device may be used on other materials, in some cases advantageously, in others not. From experience he may find that, in spite of his initial doubts, his memory is not so bad, and this feeling of confidence may recur whenever any task of memorizing is presented. He may actually acquire greater fondness for trying his skill in memorizing and this satisfaction may be experienced in learning new materials. On the other hand, he may acquire habits of using ineffective associations, of disliking such work, of doubting his capacity to improve and, when transferred, these habits would interfere with achievement on new data. *What is carried over, then, is not an improved faculty of memory, but a group of new devices, ideas, attitudes—in a word, a new technique,* which may be good or bad in whole or in parts. Habits acquired in one type of memorizing, however, are by no means invariably carried over. The change from non-sense syllables in a list to digits in a row, or to isolated names and dates, or to prose and poetry may offer so few common elements that the subject starts almost anew to acquire a technique fitting the new material.

Unconscious Transfer of Methods and Movements.—Some of the reactions carried over from one function to another are not consciously identified or appreciated. In memorizing, students are often unaware of just what devices they are using, much less of the circumstances under which they were originally acquired. If one practices hand ball for several years before taking up tennis,

it will probably be found that the ability to follow the course of the ball, to estimate bounding, and to make many adjustments of the body, carry over advantageously, while other transferred habits, such as hitting with a snap instead of with a swing may be disadvantageous. Some of the conditions of the new situation elicit reactions previously made to identical conditions in old situations. In a genuine sense they *make* the subject react as he does without awareness, necessarily, on his part of how or why. Similarly, improvement in ability to memorize, observe, or reason consists in a large measure in the development of a number of little tricks of method usually poorly analyzed and poorly understood by the learner, but activated by the common elements of the different situations.

The Transfer of Facts or Information.—In the same category with specific movements, methods of attack, emotional and other attitudes, may be included acquired reactions constituting information or subject matter. During the study of arithmetic, history, or spelling, one may memorize, perceive, and reason; but in addition to the training in these processes one acquires information. Facts learned in one situation may transfer like other reactions, in the sense that they may be utilized in other situations. That knowledge or subject matter is subject to transfer in the same way as movements, devices of learning and general attitudes, must be made clear, since it is frequently assumed that a fact, once learned, is of universal application—that it floats freely in the mind, ready for use in any situation.

Suppose, for example, that a child unfamiliar with division learns the following tables as they are printed:

A

$2 \div 1 = 2$	$2 \div 2 = 1$	$3 \div 3 = 1$
$3 \div 1 = 3$	$4 \div 2 = 2$	$6 \div 3 = 2$
$4 \div 1 = 4$	$6 \div 2 = 3$	$9 \div 3 = 3$
$5 \div 1 = 5$	$8 \div 2 = 4$	$12 \div 3 = 4$
....	....	....
$50 \div 1 = 50$	$50 \div 2 = 25$	$48 \div 3 = 16$

Will the facts of simple division now be available for widespread use? No, they certainly will not. Further practice must be given in mixed orders, to insure the learning of the items independently rather than as lists; for example:

B

$2 \div 2 = 1$	$10 \div 5 =$
$6 \div 3 = 2$	$2 \div 2 =$
$10 \div 5 = 2$	$8 \div 2 =$
$10 \div 2 = 5$	$6 \div 3 =$

When the pupil has mastered these items, he may be unable to solve such problems as the following:

C

10 =	5s
12 =	2s
6 =	3s

While the same $10 \div 5 =$ etc., is involved, the situation in general is so different that transfer seldom occurs. The child does not recognize these forms as problems in division. Specific practice having been given in the forms above, will the pupil now be able to compute such problems as these?

D

10 Cents =	Nickels.
25 Cents =	Nickels.

Assuming that they have not previously learned specifically to compute with money, many children will not make this transfer. Or consider the following:

E

5 cents pays one car fare
15 cents pays car fares
45 cents pays car fares

F For 5 cents you can buy 1 small loaf of bread
For 25 cents you can buy small loaves of bread

G How many 5¢ balls can you buy with 30¢?
How many 5¢ balls can you buy with 10¢?

With the tables perfectly learned, pupils fail to solve such problems as E, F, and G. The difficulty is that while the arithmetical computations are the same in the several problems, the common elements in the situation are so obscured by other details that they do not become potent except perhaps in the case of a few of the very bright pupils. Facts, in arithmetic or other subjects, cannot be acquired in any one situation in such form as to be generally applicable or transferable. A thoroughly "abstracted" notion of subtraction, or, in other words, generally applicable facility, is the outcome of acts of identifying and practicing subtraction in a wide variety of typical situations. To have a general notion of "division" means to be able to realize that this, and this, and this is a case where one should divide. To have a general appreciation of justice or a triangle is to become aware, on facing each relevant situation, that it contains the abstract element in question. In all of these situations we respond to a common, but subtle element.

The Transfer of General Attitudes and Ideals.—Along with movements, methods of attack, emotional attitudes and information which may transfer, are more general adjustments which may be called attitudes or ideals. Tendencies to maintain calm or to become nervous, to work rapidly or slowly, to work accurately or carelessly, to be self-conscious or absorbed in the task, to be honest or cheat—these, acquired in one situation, may be revived in others. The "problem," "practical," "scientific," or "artistic" attitude may indeed be built up to a very wide

applicability. But in so far as these tendencies are general, they result from widespread experience, from the acquisition of habits in each of many fields, and seldom are they, strictly speaking, universal, as the relative incapacity of most people to deal "practically" or "scientifically" with many problems outside their own field attests. Even such traits as thoroughness or honesty are not to be found universally or not at all in a person's behavior. On the contrary, they are associated with and aroused by a particular number of situations in the case of each individual.

The facts of transfer contain certain implications concerning methods of developing mental abilities and certain implications concerning the nature of the mental functions. We shall take these up in turn.

Some Practical Applications of the Facts of Transfer.

The main applications of the facts of transfer are related to:

1. The need of specific training in each type of ability.
2. The use of general methods for securing economy in learning.
3. The selection of subject matter.
4. The need of broad training.

The Need of Specific Training.—The first fact, that each type of ability includes techniques and devices that are specific, is illustrated by reading. It has been shown that reading is not a single ability acquired once and for all by some one type of training but embraces many types of abilities each in certain respects different from others. To give a few examples: we may read unselectively, giv-

ing all words or ideas equal weight, or to single out the main ideas, to perceive the outline, the topic sentence or the key word, to answer a particular question, such as "Why," "When" or "How." We may read with passing interest only, for temporary or more permanent retention. We may read every word, or "skim" rapidly, or change pace; we may reread to pick up the thread of a story, to detect parts overlooked, to verify an outline or to observe misspellings. There are other types of reading and it is now recognized that learning one is not learning others. Competent teachers, having selected the type of reading reactions that are deemed worthy of acquisition, set up specific practice for each type. To be sure, there is usually transfer but in the main it is not great enough to depend on wholly. Each type of reading embraces little devices that are peculiar to it; no one type is exactly another.

What is true of reading is true of observation, memorizing, reasoning, indeed, of mental activity of any type in any field. No ability comes wholly fortuitously. However great general ability, however rich general experience, in each function there are many elements that can be acquired only by specific adaptation. Even to each new pair of shoes, new automobile, or acquaintance specific adjustments are required, however great past experience may have been with other shoes, automobiles, or acquaintances.

The General Methods of Learning.—The more subtle devices and attitudes, just considered, are not easily transferred by deliberate intent. Contrasted with these obscure techniques of learning, many of the general methods mentioned in the preceding chapters may be more generally applicable. Indeed, aside from well directed and controlled specific practice the most promising pos-

sibility of improving mental efficiency is to be found in the use of general methods. To distribute reviews properly, to use the whole method, to work intensively for the purpose of improving, to avoid "crutches," etc., are devices that may be widely utilized. Other methods equally important such as keeping alert for errors, being analytic, or being systematic in reasoning are not so readily transferred. It usually requires a good deal of practice to acquire such habits of work in one field and on turning to another, a period of adaptation will almost always be needed. It will, in short, be a mistake to assume that memorizing a group of rules concerning economical methods of learning will be enough to increase one's efficiency in all fields of learning. Indeed, it will be a mistake to assume that mastery of the good methods in any one type of learning will insure their operation in others. The methods must be put to work; they must be actively habituated to be of service.

The Choice of Subject Matter.—For two reasons we may expect a greater transfer to the activities of daily life from subject matter which is itself directly useful in situations commonly encountered outside of school or college. First, in order to deal with the situations in life, as we saw in the preceding chapter, we need to know the facts involved. We cannot solve problems without information any more than we can play a violin or operate a typewriter without the specific skills, no matter how intelligent or reasonable we may be. Second, the transfer of methods of attack, interest, poise, devices of learning or reasoning, habits or ideals of accuracy, thoroughness, or initiative to the situations in life will be great to the degree that the subject matter of the classroom is identical with that used in the situations which life itself offers. We should, then, other things being equal, prefer

genuine life issues and widely usable facts to unreal and fantastic problems or trivial, unusual or academic facts.

There remains the possibility that certain subjects whose content as such is not widely used in life nevertheless deserve consideration because the kind of activities demanded offer exceptionally effective opportunities for training and disciplining mind and character. Thus it might be urged that football offers exceptional opportunities for the development of courage and sportsmanship, that geometry by the rigidity of its proofs leads to better habits of thought, that Latin because of its difficulty schools concentration and persistence. In each case of this type we must be sure that the subject does train *even specifically* the habits alleged; we must also ascertain possible outcomes, such as distaste for scholastic work, which may also be developed.

The implication of such investigations as have been made is that no one subject, because of the intrinsic character of its organization, has outstanding merit in disciplinary or formal training. The sort of training derived depends greatly on the way it is taught or learned. Almost any subject may have some general value and give any or every sort of mental training in some degree. Mathematics may become a mere exercise in rote memory, distasteful and largely futile, or it may become an absorbing study activating the finest features of reasoning and imagination. What training will be secured cannot be foretold wholly from the name or content of the subject. Much depends on what reactions are exercised; but, given equally good specific training, the amount of transfer will be great in proportion as the subject matter itself is utilized in life.

The Need of Broad Training.—The mind and character may best be trained in useful fields in life itself

rather than in some narrow subject, occupation or project. When men declare that they developed will power by hoeing potatoes when they hated it, developed originality by solving puzzles in childhood, developed reasoning by studying mathematics, developed cooperativeness and courage on the football field, we may feel assured that they are in error, or at least, unusual. Any such experience may have contributed its bit, great or small, but in so far as such traits are general characteristics of a man, and are acquired rather than inherited, they are due to training in many phases of life. General development is broad development.

THE NATURE OF MIND AND MENTAL PROCESSES.

Attention, Etc., Refer to Groups of Facts.—The implications of the facts of transfer are clearly in opposition to the theory that the mind as a whole or that attention, memory and other operations are general powers or faculties. These words, we have said, are used merely as terms under which to explain a group of more or less closely related facts concerning human behavior. The facts described under these terms are aspects of the total activity of the organism. You may remember that in the first chapter it was stated that each science aims to discover and to *classify* its facts. These terms, attention, etc., are names applied to classes of facts. Let us illustrate concretely.

All the Operations Engaged in Ordinary Reactions.—Suppose you pick up a newspaper and read a joke. What is involved? Attention, to begin with. Under attention are grouped such facts as the adjustment of the sense organs and the body generally, and the resulting vigorous conscious reaction. Perception comes in too, of course—we perceive the words and the facts which the

words represent. Is memory involved? Certainly. You may say that you remember the meaning of the words and that you remember facts related to these meanings. Is reasoning introduced? It may be, especially if the point of the joke is a little obscure. You must recall pertinent facts and react to them together with the facts presented in the joke to see the point. In the relatively simple act of reading a joke, then, all the processes may be found. These processes are not independent powers but aspects—indeed, somewhat overlapping aspects—of an ordinary mental operation. Test other tasks,—pitching in baseball or memorizing a poem—and you will find that attention, perception, memory, are present and that reasoning or imagination are or may be engaged.

The Choice of Terms.—Since the several mental processes are but terms used for convenience in referring to groups of related facts concerning mental operations, different writers may use different words and more or less different types of classification. Many books on psychology use considerably such terms as discrimination, apperception, cognition, will, volition. To use these words in this book would mean not the addition of treatments of new processes or mental operations—certainly not the addition of new mental powers—but merely a rearrangement of the facts presented. We resort to the classification of facts concerning human action under terms that seem to us suitable chiefly because it is utterly impossible to describe all the facts by a phrase or even a chapter. The use of classification terms assists presentation and recall. In so doing we run the risk of giving the impression that the terms refer not to groups of facts but to separate entities, forces or faculties.

The Term Mind.—The term mind, like one of the less inclusive terms, is equally subject to erroneous concep-

tion. The mind, as psychology uses the term, is not a power or force, which may, for example, be contrasted with the body, which may influence and be influenced by the body, or which may be trained as a muscle is trained. Mind, like memory or will, is a pure abstraction; a word under which all of the facts concerning the intergrated and conscious activities of the organism are grouped. When we think of mind, moreover, we think of conscious processes, of sensations, percepts, images, emotions. And this is quite proper since such conscious processes form an integral part of the whole activity of the human organism. The term, mind, refers to these activities; not to something above, or apart from them.

Nature of Conscious Processes.—Strictly speaking, the conscious processes are themselves not independent entities. In ordinary life, we never really experience sensations all alone, apart from percepts of facts, images or recalled facts, feelings or emotions. Each sensation is fused with other processes to constitute a percept; each sensation is likely to be accompanied by a feeling, and to be a part of an emotion. The percept embraces sensations with images and other recalled processes, not all of which are as yet well described or defined, and is usually accompanied by feelings and impulses and sometimes by emotions. Feelings never exist by themselves. And so with the other processes,—they cannot be conceived as existing or functioning wholly alone. They are all but phases of the general conscious activity of the organism. They may be described more or less adequately in isolation but they do not function independently. At any one moment most of the processes are found in consciousness. When we have told all that is known about them, about their appearance in introspection, about their relations to each other, about their modes of action and their

functions, in life generally, we have done all that we can to describe the *mind* scientifically.

QUESTIONS AND EXERCISES

1. Criticise the following problems in arithmetic for use in schools in the light of facts presented in this chapter:

   Alice has 3/10 of a dollar, Mary 11/16, Kate 2/19 and Nan 9/14. How much have they together?

   Suppose a pie to be exactly round and $10\frac{1}{2}$ miles in diameter. If it were cut into 6 equal pieces, how long would the curved edge of each piece be?

   A nail 5 inches long is driven through a board so that it projects 2.419 inches on one side and 1.726 on the other. How thick is the board?
2. "Skim" the contents of the three preceding chapters and pick out the sections which have a definite relation to transfer.
3. If one should speak English until 10 years old, then speak only German for 10 years, would the ability to speak English decrease more or less during the second ten years than if one had not spoken at all, *i.e.*, been dumb during the second ten years?
4. A woman aged 30 and her daughter aged 6 came to the United States from France. Why, after two years of practice, does the daughter speak more perfect English (meaning here merely accuracy of articulation) than the mother? If both had secured the same training during the two years, which would probably have developed the larger English vocabulary (knowledge of meaning of words)? Explain.
5. William James, in his chapter on *Habit*, wrote: "As a final practical maxim, relative to these habits of will, we may, then, offer something like this: *Keep the faculty of effort alive in you by a little gratuitous exercise every day.* That is, be systematically ascetic and heroic in little unnecessary points, do every day or two something for no other reason than that you would rather not do it, and so, when the hour of dire need draws nigh, it may find you not unnerved and untrained to stand the test." Examine this statement critically and determine what the conditions would have to be for it to agree with the doctrine given in the text.
6. Would the Law of Effect have any bearing on James's statement? Would the implication of that statement be that sub-

jects should be introduced into the curriculum just because they are difficult or distasteful?

7. Compare the implication of James's statement with the following by Thorndike: "To study the distasteful that is known to be useful is of much greater disciplinary value than to study the merely distasteful. The habit of value is *to suffer that good may come,* not *to suffer wastefully.* It is in sacrificing for a greater good, not in mere sacrificing, that the mind gains. To suffer simply so as to stand suffering would be as foolish as to learn falsehoods so as to be able to unlearn them."
8. How do you suppose Thorndike would justify this statement: "The greatest disciplinary value of Latin would appear in the case, not of those who disliked it and found it hard, but of those to whom it was a charming game"?
9. Collect some statements from books on education, general reading, or advertisements which are based on erroneous notions of transfer.
10. Suppose it were found in a certain secondary school that the students who had studied geometry were better in reasoning in general than those who had not. Would you consider this satisfactory evidence that training in geometry was responsible for the greater ability in general?
11. Do you think some teachers secure a greater amount of transfer among their pupils than others do? How?
12. Show in detail how the training received in (a) athletic games, (b) grammar, and (c) psychology may be made to function in everyday life.
13. What reactions acquired in playing the piano would transfer to typewriting? To singing? What negative transfer might take place?
14. On the basis of the *general* value of studies, what changes would you recommend in the curriculum of the high school from which you graduated?
15. Will reading good literature contribute to your ability to write? To get the greatest transfer just *how* should you read?
16. How would you train a child to meet emergencies (as in cases of fire, accidents, drowning, etc.)? To what degree will mere knowledge of what to do function in face of an emergency?
17. What subjects are especially useful to develop general open-mindedness or freedom from prejudice and superstition?

GENERAL REFERENCES

More extensive summaries of the experimental work on transfer will be found in:

E. L. Thorndike, *Educational Psychology,* Vol. II, New York: Teachers College, 1913, Chapter 12; Daniel Starch, *Educational Psychology,* New York: Macmillan, 1917, Chapters 13 and 14.

As regards theories or interpretations of the facts of transfer, there are differences among authorities. Several more or less divergent points of view will appear in the following:

C. H. Judd, *Psychology of High School Subjects,* New York: Ginn, 1915, pp. 392-435; J. R. Angell, C. H. Judd, and W. B. Pillsbury, short articles in the *Educational Review,* June, 1908, pp. 1-42; G. M. Stratton, *Developing Mental Power,* Boston: Houghton Mifflin, 1922; J. E. Coover, *Formal Discipline from the Standpoint of Experimental Psychology,* Princeton: Psychological Review Monographs, 1916.

REFERENCES TO STUDIES UTILIZED IN THE TEXT

William James, *Principles of Psychology,* New York: Holt, 1890, Vol. I, pp. 666-7.

W. F. Dearborn, "Experiments in Learning," *Journal Educational Psychology,* June, 1910.

W. G. Sleight, "Memory and Formal Training," *British Journal of Psychology,* 1911, pp. 386-457.

E. L. Thorndike and R. S. Woodworth, "The Influence of Improvement in One Mental Function upon Efficiency of Other Functions," *Psychological Review,* 1901, pp. 247-261, 384-395, 553-564.

L. W. Kline, "Some Experimental Evidence on the Doctrine of Formal Discipline," *Bulletin of the State Normal School,* Duluth, Minn., Feb., 1909.

T. H. Briggs, "Formal English Grammar as a Discipline," *Teachers College Record,* 1913, No. 41.

A. I. Gates and D. Van Alstyne, "The General and Specific Effects of Training in Reading," *Teachers College Record,* March, 1924.

CHAPTER XVI

THE INFLUENCE OF INTERNAL AND EXTERNAL CONDITIONS UPON EFFICIENCY.

Nearly everyone has a number of convictions concerning the influences of various conditions such as fatigue, interest, the weather, time of day, noise, coffee and tobacco upon behavior. Long the subject of speculation and opinion, many of these conditions have been subjected within recent years to experimental study.

Any factor, noise or alcohol, may be examined in its relations to several phases of behavior such as bodily comfort, particular internal sensations, moods, desires, ambitiousness, nervousness, speed and efficiency in learning or performing as well as in its relations to general health, vigor or happiness. In the discussions which follow, we shall be limited mainly to the influence of several factors upon efficiency in performance or learning during the time the factor is active. We shall be concerned, then, primarily with the immediate effects of the conditions imposed on efficiency of some type.

The Influence of Motivation.

Motivation during Short Periods.—The potency of certain motives in influencing achievement is first in importance and magnitude. It is illustrated in pronounced form by an experiment upon college students (Knight and Remmers). Ten college Freshmen, after being subjected for five days to severe humiliation, hard work, loss

of sleep, hazing and general torment, were given, late at night, a series of tests in computation, the results of which the Freshmen were convinced, would have considerable weight in deciding their fitness for admission to a college fraternity. The motivating factor was their desire to qualify for membership. A series of five-minute tests were given with but short intervals between. The results of these tests were compared with those obtained from fifty college Juniors whose work was not motivated in any special way. As regards intelligence, age and arithmetic ability, it may be assumed that the Juniors were at least as good as the Freshman; as regards physical fitness they certainly possessed a striking advantage. The Juniors, however, during the seven five-minute periods averaged 9.6 problems correctly solved per period, whereas the tired Freshman during their first seven tests averaged 18.3 problems per period, or twice as many. Since in every other respect the Juniors had the advantage, the differences in achievement must be credited to the factor of motivation.

Motivation over Longer Periods.—That the influence of motivation is not necessarily limited to a temporary spurt, and that it results in stable improvement when so utilized as to affect practice has been disclosed by several studies. In one of these (Kitson) the daily output of forty hand compositors in a Chicago printing establishment was followed for a year during which motivation was provided by giving a cash bonus for increased productivity and by the recording and display of evidence of improvement. These men were mainly experienced workers with periods of service in the trade from 2 to 27 years, and an average of 10.3 years. Many had been working on a dead level of efficiency for years. Under the influence of the incentives, the men, young and old,

began to improve. After five months their output was 67 per cent greater. Since these men were more experienced and therefore presumably more fixed in their habits, they improved less on the whole than the less experienced men. There were some striking exceptions, however. One man for example who had been in the trade for 27 years increased his output 142 per cent.

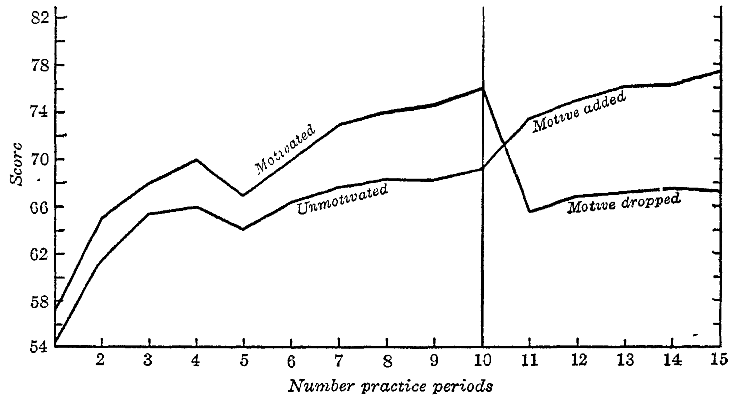


FIG. 51.—SHOWING THE INFLUENCE OF DISCLOSING EACH DAY TO THE SUBJECTS THE SCORES MADE IN THE PRACTICE PERIOD. The task was the writing of as many legible "a's" as possible during a 30 second period. During the first ten practice periods, the group thus motivated made greater improvement than the group which did not learn the results of its work—the unmotivated group. From the tenth day, the motivation was reversed. The first group, now not permitted to see their progress, begin at once to lose, whereas the other group, on studying their scores, progress rapidly. (Modified from W. F. Book, *Pedagogical Seminary,* Dec., 1922.)

Varieties of Motives.—The varieties of motives are numerous. The most potent motives have their roots in the dominant human urges described in Chapter IX. The mere display of the achievements at the end of each practice period arouses a very potent urge to improve. A sample of the experimental findings in which knowl-

edge of results serves as a motive is shown in Figure 51. In this instance the learners aware of their progress from day to day are stimulated to greater achievements, and when the incentive is removed efficiency deteriorates at once. Rivalry produced by the sight and sound of others working and especially by the awareness of the achievements and gains made by others as well as by one's self is an effective form of urge to improve. Several investigators have found that children work better and faster and improve more rapidly when working together under the spur of competition than when working alone. The circumstances surrounding a "test" in the classroom or the psychological laboratory usually spur the subject to greater effort than under ordinary circumstances. The presence of the experimenter looking on and the presence of other subjects taking the test at the same time seem to produce greater effort than is secured when the subject works alone.

In these studies the potency of motivation resulting from influences affecting the subject during a period of work is very pronounced. Obviously one may work at various levels below the maximum. The level presumably depends upon the effort which in turn varies with the type of motivation. These facts complicate the task of ascertaining the effects of other factors such as coffee or noise upon performance. Provisions must be made to isolate the physiological effects of coffee upon efficiency from the effects of other conditions surrounding the test which act merely as spurs to effort. Before leaving the topic of motivation it will be desirable to see under what conditions maximum effort may be secured; whether it is a stable or unstable condition and whether certain types of motivation may be so powerful as to disturb and reduce achievement rather than increase it.

The Influence of Complimentary and Disparaging Remarks.—Complimentary and disparaging remarks addressed to a performer or learner by another, as for example, by an experimenter, may act as an incentive to greater effort. Like any other form of motivation they may cause a subject to try to do his best, or when applied to a person already trying hard they may stimulate him to extraordinary effort which may conceivably have either a beneficial or disturbing effect on efficiency. To ascertain the specific effects of the remarks it is necessary somehow to render constant the influence of other motives, that is, to insure equal effort in the series of tests required as well as to take care of the influence of improvement due to practice. This was done in a study with college women as subjects (G. S. Gates and Rissland). The women were at first tested individually in speed of naming a series of colors and in speed of tapping with a pencil-like stylus under conditions that usually secure great effort. Following each test of each woman in the case of one-third of the number, such disparaging remarks were made as these: "Oh dear, this is really a very poor score. I am afraid that you are at the bottom of the group, etc." Following each test of another third, complimentary remarks were offered such as "That is really splendid! Your score is way up at the top of the group." To another third—the control group—no remarks were made. Every woman, following the remarks, was asked to take the tests again, those who were disparaged presumably to improve a poor showing, those complimented to further increase their score, those of the control group for no stated purpose. By comparing the differences between the results of the first and second tests of the two motivated groups with those of the control, the specific effects of the remarks are disclosed. In

general, it appeared that either type of remark produced improvement as compared to no remark at all but the gains were small. In exceptional cases, and these mainly among poor rather than among good performers, the influence of disparagement was unfavorable. In the main, however, the motivation produced by the presence of the

Showing the Average Gains or Losses in a Second Test Taken before the Experimenter Alone, before a Small Audience or before a Large Audience.

(From G. S. Gates)

Average Gain or Loss (—) in Per Cent.

	Coordination Test	Color-Naming Test	Analogies Test	Word Naming Test	Average of All Four
Second test before experimenter alone...	6.4	7 2	14.0	0.10	6.9
Second test before small audience.....	7.0	5.1	6.1	—2.0	4.0
Second test before large audience......	4.9	4.8	11.0	7.7	7.1

experimenter and the general setting of the experiment was but little changed by such remarks as were made.

The Influence of Observers.—The mere presence of an investigator and the general experimental setting is apparently a decidedly potent incentive. Whether the addition of other observers, or of a considerable audience, would provide a more effective motive or result in a decrease in achievement, was the subject of another study. College women were the subjects; several tests of mental and motor functions were used. Each subject was first tested by the experimenter alone, then in the case of twenty-five women the test was repeated in the presence of the experimenter alone; each of another twenty-five took the second test before a group of four to six observ-

ers, and each of a third twenty-five took her second test before an audience of from twenty-seven to thirty-seven observers. The members of the audience observed attentively but made no remarks. The presence of the audience resulted in no constant increase or decrease in comparison with the achievements of those taking the second test in the presence of the experimenter alone, as shown in the table on page 474. The differences vary from test to test and on the whole they appear to be due to chance factors rather than a consistent effect of the number of observers.

Motivation in Experimental Settings.—In all of the studies of motivation, individual differences are found. Some persons appear to require little special motivation to put forth their best efforts; others require considerable. Some are relatively little influenced by conditions that act powerfully on others. Some are very stable in performance under extreme effort; others may by trying too hard become confused and show a decrement in achievement or break down entirely. Some are disturbed by factors which merely stimulate others to the optimum degree. The studies of motivation indicate that in investigations of the influence of other factors, alcohol or fatigue, the experimental situation should include a strong but not excessively stirring form of motivation, in order to keep the workers at maximum effort without running the risk of overstimulation. These conditions are very well fulfilled by the presence of a competent experimenter, the general laboratory situation, and a certain amount of encouragement of the subject to do his best. Adding to these factors another experimenter or assistant, or fellow workers in the tests, seems to matter but slightly in most instances. This, at least, seems to be true of college students. Probably their stability is due

to the fact that they are well disciplined in test situations, in doing mental and motor tasks in the presence of an instructor, with and before groups, and to experience in controlling themselves in the face of praise and reproof and the usual distractions of a classroom or laboratory. It is entirely probable that children or individuals picked at random from the community would be more profoundly affected both favorably and unfavorably by variations in the motivating conditions. Because of their stability of performance under moderate motivation, college students are especially good subjects for investigations of the effects of other factors, to which we shall now turn.

The Influence of External Conditions.

The Influence of "Bad Air."—It is popularly believed that in poorly ventilated rooms, carbon-dioxide and other toxins from expired air result in drowsiness, lassitude, headaches, and loss of efficiency. Pure air contains about 21 per cent of oxygen, 78 per cent of nitrogen, and 0.03 per cent of carbon-dioxide. In a very crowded and ill-ventilated school room the carbon-dioxide may be increased to 0.3 per cent and the oxygen decreased to 19 per cent, but these changes are insufficient to produce the effects ordinarily observed. When the air is cool, of favorable humidity, and in movement, the oxygen content must be reduced to 2.4 per cent before ill effects are produced. When the air is hot and of unfavorable humidity, the ill effects are not relieved by breathing pure air through a tube from the outside. High temperature or humidity or both, then, rather than low oxygen content and expired matter, seem to be the causes of discomfort.

Temperature and Humidity.—The influence of stale air, high and low temperature and humidity in various combinations has been studied by Thorndike and several

psychologists working under the auspices of the New York State Commission on Ventilation.

It was found that adult subjects when urged to do their best could perform quite well and improved in efficiency quite as much when working in hot, humid, stale, and stagnant air (temperature 86° Fahrenheit, humidity 80 per cent, with no fresh air and no movement in the air) as when they were working under "optimum" conditions —namely, a temperature of 68° Fahrenheit, 50 per cent relative humidity and 45 cubic feet of outside air per minute for each person. It was furthermore found that when the subjects were given very uninteresting work and were given no special incentives to do well, they still did as much and as well when working eight hours a day in the hot, humid, and stale air as when working under optimum conditions. Finally, when individuals were given their choice of doing mental work, reading stories, resting, talking or sleeping, they did quite as much work when the temperature was 75° as when it was milder, 68° Fahrenheit.

The influence of extremely low humidity, with temperature kept constant at 75° Fahrenheit, was found to have no perceptible effects upon efficiency or improvability. A squad practicing arithmetic, typewriting, and other functions during the regular working day, and under ordinary motivation, with the humidity reduced to 20 per cent, improved as rapidly as a squad working under the "ideal" degree of humidity, 50 per cent (Stecher).

The atmospheric conditions which are encountered in ordinary life, then, however uncomfortable some of them may be, have no appreciable effect upon efficiency in performance, or on improvement in mental and light motor work when moderate motivation is present. Whether long continued exposure to very hot, very moist, or dry

air would occasion a good deal of wear and tear on the body or injure health, is another problem not as yet solved. The results of the psychological investigations indicate merely that if severe atmospheric conditions, as in mid-summer, must be faced one may as well be cheerful. At least, it is unlikely to be too hot to make mental work unprofitable. It is possible to learn as well when it is hot as when it is cool, when it is moist or dry, or when the humidity is moderate.

The experimental studies have a bearing on the perennial topic of the effects of weather and climate upon human feelings and efficiency. That human beings do become adapted rapidly to the most forbidding climatic conditions of the globe is not surprising in the light of experimental studies in which adjustments are effectively made to abrupt and extreme changes in humidity, temperature, and staleness. While climate and weather includes in addition to these factors others such as density of the atmosphere, light and possibly electrical conditions, the probability is that adaptation to these is equally facile.

Illumination and Color.—The most essential feature of favorable illumination is an evenness of distribution of light, especially the absence of glare or contrast in the field of view. Artificial or window light should therefore come from above, behind, or at the sides. Contrasts in walls and hangings, glistening paper, or polished instruments contribute to eye fatigue. A second desirable feature is illumination of moderate intensity. Lights are more often too bright than too dim. Particularly unfavorable intensities and brightnesses are often produced by the use of high power electric lights. A soft even light from indirect or semi-direct systems is most satisfactory.

There are many opinions concerning the effects of

colors of lights or surroundings on efficiency, disposition and health, but the findings of experimental investigations have been mainly negative. The most significant difference between light from an uncolored globe and light from a colored globe is that the colored light is less intense, since the colored glass absorbs some of the rays. It has been found (by Pressey) that the more intense light is more stimulating, but the difference is small. What little is gained by means of the stimulating effect of intense light is probably more than compensated for by its fatiguing effect upon the eyes. Colored glasses are restful only because they reduce light intensity. It makes little difference what particular color is used.

Auditory Distractions.—Just as the organism becomes adapted to wide difference in light or temperature, so it becomes adapted to persistent sounds of the street, conversation, rattling of typewriters, or the roar of machinery. When adults are well adapted to a working condition, new distractions are apparently at first disturbing, although they have little effect on the output. Experiments conducted in the laboratory (by Morgan) indicate that when a subject is well adapted to a working condition, the introduction of a new disturbance causes but a slight and temporary decrease in efficiency, although it may be decidedly annoying. The subject soon arouses himself to overcome or adjust to the noise. His output is then kept up to the norm, often actually surpassing it, but in so doing more than ordinary energy is consumed. He may pound the typewriter keys harder, grit his teeth, articulate, and contract various muscles. These superfluous activities drop out gradually as adjustment is perfected, just as irrelevant reactions tend to be eliminated in all forms of trial-and-error learning. The general rule seems to be that when a new disturbance is

encountered, the worker sets about to acquire by trial and error an adaptive reaction to it and often succeeds in so doing without appreciable deterioration of his output during the process.

The Influence of the Time of Day.—Under the conditions of an ordinary day, what is the relative efficiency in mental and motor performances at different hours? In one investigation, the pupils of several grades were repeatedly tested in representative tasks at different periods until the accumulated results gave a fairly accurate measure of achievements resulting from maximum effort at different hours of the day. The results are given in the table below.

VARIATION IN EFFICIENCY DURING THE DAY
(From Gates)

The Achievements at the Several Hours Are Proportional to That at the 9-10 *A M. Hour Which Is* 100.0 *in Each Case. Average Results for* 240 *Pupils from Grades* 5 *and* 6.

TIME	9-10 A M.	10-11 A.M.	11-12 M.	12-1 P.M.	1-2 P.M.	2-3 P.M.
1. Addition	100.0	102.4	104.2	....	102 3	103.0
2. Multiplication	100 0	101.9	105.1	....	100.9	103.0
3. Memory for Auditory Digits	100.0	105.9	106.7	....	99.4	102.4
4. Memory for Visual Digits.	100 0	103.2	109.2	....	99.1	103.4
5. Recognition of Non-Sense Syllables	100.0	104.7	105.3	....	100.0	103.7
6. Completion	100 0	105.0	109.7	....	106.2	108.8
Average	100 0	103.8	106.7	....	101.3	104.1
7. Cancellation	100.0	101.8	104.4	....	104.9	105.5
8. Speed and Accuracy of Tracing	100.0	104.6	106.7	....	109.5	111.2
Average of 7 and of 8. .	100.0	103.2	105.6	....	107.2	108.4

In the more strictly mental functions such as addition, multiplication, visual and auditory memory, recognition

and completion, efficiency is lowest in the first and highest in the last morning period. A slight drop follows the lunch period with a subsequent rise between two and three o'clock. Other investigations have shown a very similar distribution of efficiency for gross bodily functions, such as shoveling and lifting. Efficiency in motor skills, such as cancellation and tracing, is somewhat greater in the afternoon than in the forenoon.

Similar average results were obtained from a group of college students tested at all hours, except noon, from eight A.M. to five P.M. An interesting feature of this investigation was the disagreement between the distribution of actual ability and the distribution of self-judged ability. Most students were quite mistaken about the hours of their maximum efficiency, doubtless because they were misled by feelings of fatigue which were often most acute at the periods of highest efficiency.

One thing is quite certain: the ordinary work of the school day is not so severe as to reduce efficiency perceptibly. In fact, achievement is higher at nearly every hour than it is at the beginning of the day. In the main, the differences are small. Aside from the suggestion that such functions as writing, drawing, or other light work requiring speed and accuracy of movement might well be done in the early afternoon period, it would appear to make little difference at what hours mental work is pursued.

The Influence of Continuous Work.

Continuous Muscular Work.—The effect of continuous work in a function upon efficiency in it, as measured by the amount and quality of the product (words written, facts learned, etc.), varies considerably with the function.

In the case of hard muscular work the decline in effi-

ciency is rather steady and pronounced. Figure 52 shows the relative distances through which the middle finger pulls a load of about six and a half pounds making a pull every two seconds. The muscle soon is incapable of lifting the load although it is not entirely exhausted as

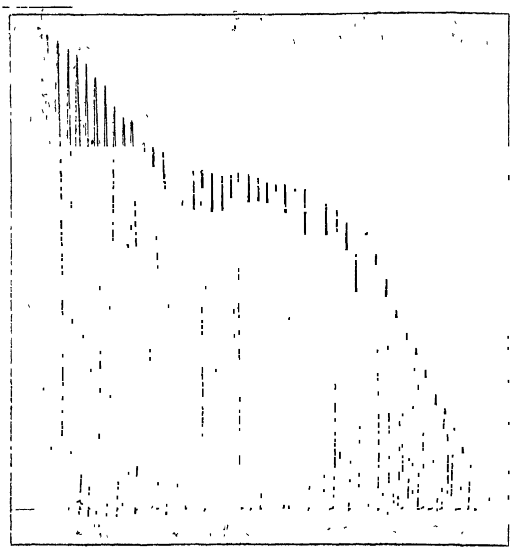


FIG. 52.—THE VERTICAL LINES INDICATE THE RELATIVE DISTANCES THROUGH WHICH A WEIGHT OF 6½ POUNDS IS PULLED BY THE MIDDLE FINGER OF THE RIGHT HAND. Contractions were made at intervals of two seconds. (From Howell's, *A Textbook of Physiology*, 5th Edition, p. 48.)

shown by the fact that it can still lift smaller weights. A rest of about two hours would be required before the muscle could repeat the original performance. If sufficient rest is given between the contractions, the muscle will lift the load a much greater number of times. If a muscle in some other part of the body, the other arm, for example, is working at the same time, the finger loses its

strength more rapidly possibly because of the fatigue products circulating in the blood. Loss of sleep or food, and doses of alcohol and certain other drugs, decrease the efficiency of the muscle, whereas sugar, adrenalin, and certain other chemicals increase efficiency.

Muscular work of this sort uses up definite materials such as glycogen and develops by-products such as carbon dioxide, which together reduce the capacity to function. Unpleasant sensations, pain, or so-called "feelings of fatigue" are also produced, along with definite impulsions to cease the work.

Continuous Work of the Neurones.—The effect of continuous work by isolated neurones may be observed experimentally. One method employed is to dissect from a freshly killed frog a large muscle with a long motor nerve attached. Such a "nerve muscle preparation" can be kept alive for a long time. If the stump of the nerve is stimulated by an electric shock, the nervous impulse thus occasioned discharges into the muscle and causes a contraction. If contractions are provoked rapidly, the muscle soon fails to respond. Whether the loss of capacity is due to fatigue of the nerve or to fatigue of the muscle may be determined by an experiment. If a bit of the drug curari is placed on the nerve near the muscle, the nerve impulse is blocked at that point so that it fails to activate the muscle. It has been found, however, that the impulse passes along the nerve as far as the point at which the drug is applied, *i.e.*, that the neurones are conducting as under ordinary circumstances. Investigators have found that even when the nerve is stimulated several times per second for ten hours or more, removal of the effects of curari results in the renewal of the muscular contractions upon stimulation of the nerve thus demonstrating an extraordinary resistance to

"fatigue" on the part of nerves as compared to the muscles.

Continuous Mental Work.—Mental work usually involves the activity of muscles as well as neurones of the central nervous system. In reading, the muscles of the eyes, at least, are engaged; in writing compositions and in arithmetic, the muscles of the eyes, hands, and arms

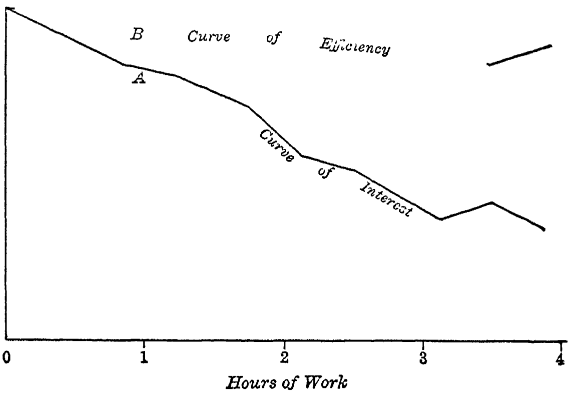


FIG. 53.—CURVE A SHOWS THE RAPID LOSS OF ZEAL OR INTEREST IN GRADING ENGLISH COMPOSITIONS DURING A PERIOD OF 4 HOURS. The curve is an average for 5 subjects. Curve B shows the loss in efficiency, represented by a combined score for speed and quality of work, during the same time by the same subjects. The greatest loss of efficiency (near the end) is about 7 per cent. (Modified after Thorndike.)

are active. Even in "mental" arithmetic, spelling, or ordinary thinking, muscles of the eyes, the vocal organs, and probably other parts of the body are involved to some extent. And in all types of mental work, the maintenance of the body's position depends upon muscular adjustments. Thus, what we call "mental fatigue" is in part the result of muscular work and identical with muscular fatigue.

When one has been working continuously at spelling,

arithmetic, reading, composition, or some other mental task, he may become aware of a group of sensations which technically have been called "feelings of fatigue," usually unpleasant in character. Feelings of fatigue are, in a large measure, sensations from muscles, tendons, and joints, and include feeling of numbness, aches, and pains from the eyes, head, back, and other parts of the body. With these are fused other sensations derived from visceral, arterial, and other organic conditions. The whole constitutes the familiar feeling of fatigue which is usually accompanied by impulses to stop working. If the work is continued it becomes tedious or distasteful.

The progressive course of feelings of fatigue and annoyance produced by continued work is pictured roughly in Figure 53, which is based upon the judgments of a group of adults obtained during four hours of continuous work in grading English composition. Highly interesting at the beginning, the work became progressively less pleasant, until at the end of the fourth hour it was clearly distasteful.

Feelings of fatigue and loss of interest are commonly accepted by workers as indicative, at least approximately, of a decreased state of efficiency. But that these symptoms are extremely misleading has been found repeatedly when the quantity and quality of the output has been measured during periods of continuous work. In Figure 53, the distastefulness of the work in the case of grading compositions, for four hours continuously, is plotted together with the output. The loss of ability is not nearly as great as the loss of satisfaction in the work.

Many investigations of continuous mental work have yielded similar results. Two or three hours of continuous work at maximum effort produces a temporary decrease in the product of not over 10 per cent, and in most func-

tions less than that. By a temporary decrease is meant one which is curable by a rest of an hour or less. Of course, the curve of work is marked by all sorts of fluctuations, some of them peculiar to particular individuals, and efficiency may drop more decidedly if the worker eases up. But on the whole, continuous work in mental functions shows a small loss in output as compared to that found in continuous muscular work. If we make mental work as difficult as we can, taking for our task the mental multiplication of such numbers as 8372 and 3458, for example, we find that, as demonstrated by one experimenter (Arai), it is possible to keep it up for 12 hours at a stretch. The result of long continued difficult mental work is thus in sharp contrast to the effect of hard physical work. While feelings of physical fatigue may be fair indices of physical capacity, they yield by no means reliable evidence of mental efficiency.

So far as mere loss of efficiency is concerned, there is little to urge against long continued work of the same sort. But what of other effects? Too lengthy application to a task *may* make the work uninteresting or positively repugnant. When the work becomes distasteful or exasperating, it probably indicates an unfavorable organic stirring-up somewhat similar to that observed under emotional irritation or excitement. This general state is indicative of a considerable organic wear and tear which may become injurious if long continued. But it is the repugnance, exasperation, excitement, or worry produced by mental work rather than the work itself which is harmful. If one can school himself to maintain interest and enjoyment in the task, the ill-effects of long and hard mental work may be tremendously reduced. There are, of course, limits to the amount of mental work one may safely do because of the muscular fatigue and the depriva-

tions of recreations, exercise, rest, and sleep which too persistent work may bring. Just how long a person may safely do mental work depends partly upon his general strength and stability, partly upon his susceptibility to excitement and worry, and partly upon his interest.

The "feelings of fatigue" are in part, if not mainly, the results of muscular activity and strain. Much may be done to lessen unnecessary and often damaging fatigue, particularly of eye and hand. For example, the task of copying problems to be computed in arithmetic or algebra, facts to be learned, etc., is not only harder work, minute for minute, than computing or memorizing, but much more monotonous. It is, moreover, as unnecessary as it is fatiguing. Less worry about the disastrous effects of "mental fatigue" and more attention to muscular fatigue of eyes, hands and the body is one suggestion which the experimental studies of mental work have to offer.

General Conclusions.—Other types of experimental evidence on the remarkable capacity of the organism to adapt itself to unusual conditions have been obtained. For example, students during periods of from 30 to 48 hours without sleep, although subject to pronounced "feelings of fatigue" and other uncomfortable symptoms, were nevertheless able to perform mentally as efficiently and learn as effectively as under ordinary conditions (study by Robinson). During a fast of 31 days, a man (studied by Langfeld) showed no appreciable loss of mental efficiency and ability to learn, although the decrease of bodily weight and strength was great.

In the study mentioned above (Knight and Remmers) some of the subjects during five days were given Hinkle's pills, not permitted to shave or bathe, were forced to carry with them everywhere weighty articles, were

"paddled" with barrel-staves, forced to eat raw liver ("ostensibly dog-meat"), were subjected to realistic but fake "brandings" and otherwise hazed, were allowed only one or two hours of sleep in twenty-four, and during the twenty-two waking hours were required to do menial work about the house, or go "frequently" on hikes of 12 to 15 miles, in addition to carrying on their regular university work. Despite all of these hardships, under strong motivation, they appeared to do simple mental work as well as usual. Such facts bear witness to the remarkable stability of the mechanisms involved in well habituated mental activities. It is surprising that these functions, which may be so readily allowed to operate below maximum in the absence of incentives, remain unimpaired in efficiency, during and after such extreme deprivations and exertions. The facts attest, also, to the remarkably effective and facile adaptability of the human organism to unfavorable conditions imposed upon it.

Some of these adaptive reactions—to heat, cold, low humidity, continuous work, loss of food—appear to be directly instinctive; that is, they are carried out as in the case of the infant, by adjustments inborn rather than learned. The adaptations to new noises, or visual distractions, while involving instinctive acts, are nevertheless, in a genuine sense, acquired. The process of overcoming an auditory distraction affords, as we have said, a beautiful example of the trial-and-error learning in which elimination and selection continues until the adjustment becomes easy, smooth, and nearly unnoticed. That these adaptations are, however, really active adjustments is indicated by the fact that when the stimulus, to which an individual is adapted so completely that it is unnoticed, *is removed,* he becomes aware of the change and must make another adjustment to the rearranged

conditions. Thus, when one is adapted to a certain rattle or roar in his working environment, removal of the sound may be temporarily disturbing, although readjustment is shortly achieved.

The Influence of Drugs.

Caffeine.—Caffeine is the active drug in tea, coffee, and many soda-fountain drinks. An average cup of hot black tea contains 1.5 grains; an after-dinner coffee about the same; an average glass of cold green tea about 2.0 grains; and a large cup of coffee about 2.5 grains.

Employing a squad of 16 subjects whose food, sleep, rest, and work were controlled during an experiment which extended over 40 days, the influence of doses of caffeine ranging from two to six grains upon various mental and motor functions was measured (Hollingworth). Effort to work was insured by prizes, display of rewards, and other incentives. The effects of suggestion and anticipation were eliminated by administering the drug in disguise. At uniform intervals the subjects were given a mixture which sometimes contained and at other times did not contain the caffeine.

The effect of a dose of caffeine appears usually within an hour and lasts for several hours, depending on the size of the dose. This substance usually produces a decrease in muscular steadiness and tremors which appear more quickly and last longer with larger doses. In typewriting, greater accuracy results from using the drug, while speed is also increased except by large doses which reduce the rate of writing. In more purely mental work —naming the opposites of words, naming colors, adding, etc.—efficiency was increased by doses of all sizes for periods varying from three to seven hours. In the task of crossing out certain numbers from rows of mixed num-

bers doses of four grains or more produced improvement in ability which sometimes persisted for nearly 24 hours. The stimulating effect of the drug was indicated by the fact that a dose of six grains disturbed the sleep of most subjects, and on some much smaller doses had a similar effect. The stimulating influences of caffeine, contrary to general opinion, is not followed by a subsequent period of depression, at least not within 72 hours.

It should be understood that tea, coffee, and other caffeinic beverages contain other substances which may enhance or neutralize the effects of caffeine or produce still other effects, good or bad. What influence the long continued use of this drug may have on the body is not known, but during a period of 40 days, in so far as integrity and proficiency in mental work are concerned, caffeine has distinctly an accelerating effect without any observable harmful results.

Tobacco Smoking.—To determine the effects of tobacco smoking upon efficiency or improvement during mental work is exceedingly difficult. Statistics gathered concerning groups of smokers and non-smokers are interesting but worthless since the groups may differ in many other habits as well as in the use of tobacco. If habitual smokers are used as subjects, the mere deprivation of the exercise of the habit may disturb their attitude toward work. If subjects unaccustomed to smoking are used, the effects of tobacco will not be typical of the effects on the average smoker. If we are interested in the effect of tobacco alone, it is essential that the subject should not know when he is really smoking tobacco and when he is not, since the mere idea of smoking, the pleasure (or displeasure in the case of the unhabituated) or the stimulation provided by the sight, taste and smell, may produce the result rather than the drug itself.

By means of an ingenious pipe, heated by an electric coil, it has apparently been possible to deceive the smoker (Hull). When blindfolded, the subjects were unable to tell whether they were really smoking tobacco or the slightly moistened warm air through the control pipe. Eighteen students, nine habitual and nine non-smokers, were tested in a number of functions on each of eighteen days. Each day the subject took the series of twelve

PERCENTAGE GAINS INDICATED BY (+) AND LOSSES (—) PRODUCED BY THE INFLUENCE OF TOBACCO UPON 18 SUBJECTS (Experiments by Hull, reported by O'Shea in *Tobacco and Mental Efficiency*).

Tests	*Per Cent*	*Tests*	*Per Cent*
Rate of pulse beat	+ 6 09	Memory span	—5.07
Speed of tapping	— 0.35	Speed of adding	+1.04
Muscular endurance	— 5 76	Accuracy of adding	—5.55
Steadiness of motor control	—42 12	Reaction time in reading	+0.38
Speed of cancellation	— 1.02	Facility in learning	—4.42
Accuracy in cancellation	— 7.09	Learning reaction time	+2.31

tests, and then began to smoke, on some days a pipe filled with real tobacco, on others the fake pipe. After beginning to smoke, the subject went through the series of tests three more times, with brief intervals between. The results of this study show that the influence of tobacco smoking is a rather variable matter. With some the immediate effects are detrimental but after an hour or so of continuous smoking they pass off, leaving the performance uninfluenced, or, rarely, slightly improved. With others the immediate effect may be beneficial while continued smoking brings on unfavorable effects. On the whole, the tobacco seemed to slow down and disturb the mental abilities tested slightly. The effects were little more pronounced in the case of the non-habitual smokers. No individual was always unfavorably influ-

enced in all of the tests, however; there was only a *tendency* for tobacco to exert a detrimental influence more frequently than a favorable influence. The average of results for all individuals during the nine smoking days for each function is shown in the accompanying table.

The average result for all subjects in all tests was a loss of about 5 per cent. Tobacco smoke rather uniformly accelerated the heart beat and reduced steadiness of motor control; these were the most consistent and pronounced effects.

Concerning the effects of tobacco on general health, ambitiousness, creative inspiration and the like, there are opinions in abundance, but no reliable data.

Alcohol.—The influence of alcohol, administered in its pure form, diluted with water or beverages, upon efficiency in various mental and motor functions has been investigated on several occasions with results which agree in the main. An English psychologist, Rivers, was the first to disguise the alcohol property so that the subject was unable to tell by look, taste, or smell, whether the mixture contained alcohol or another harmless substance. This investigator employed tests mainly of muscular efficiency, strength, and endurance, upon which little effect was produced except by large doses of alcohol. Effects found in earlier investigations were attributed to sensory stimulation (tastes, odors, sting) or to expectation of improvement rather than to the drug itself.

During extensive and carefully controlled investigations in the Nutrition Laboratory of the Carnegie Institute, it was found (Dodge and Benedict) that alcohol had not a stimulating but a depressing effect upon mental and motor efficiency. To this statement there was one exception—the pulse was accelerated, which was symptomatic, perhaps, of internal resistance to the drug. In the case

of several functions, the losses of efficiency which resulted from doses of 30 and 45 cubic centimeters of alcohol—the results for doses of both sizes combined—were as follows:

Knee-jerk: decrease in extent of muscle contraction	46	per cent
Knee-jerk: increase in time of reaction	10	" "
Protective eye-lid reflex: decrease in extent	19	" "
Protective eye-lid reflex: increase in time	7	" "
Sensitivity to electric shocks: decreased	14	" "
Speed of eye movements: decreased	11	" "
Speed of tapping, with hand: decreased	9	" "
Speed of reading isolated words: decreased	3	" "

In all tests, the effect of alcohol is to reduce functional capacity, and this is strikingly true of the simple protective reflex activities which become more sluggish in rate and less effective in extent. No tests of mental efficiency were employed by these workers.

Decreases in Efficiency in Various Functions Produced by

	Beer Containing Total of 40–50 cc. Alcohol	*Beer Containing Total of 66–79 cc. Alcohol*
Steadiness	68 per cent	241 per cent
Tapping	7 " "	13 " "
Coördination	6 " "	10 " "
Color naming	2 " "	7 " "
Opposites	5 " "	12 " "
Adding	10 " "	15 " "
Gain in pulse rate	8 per cent	10 per cent

The influence of alcohol on both motor and mental functions has been recently investigated (Hollingworth). The alcohol dosage was administered in the form of beer which was 2.75 per cent alcohol by weight. Six trials of each test were given during the forenoon. At noon the beer was given with a small amount of food. On certain

days beer was given which was identical in all respects with the genuine except that the alcohol had been removed, thus providing a control. During the afternoon, six trials of each test were given again. In the accompanying table, the gains and losses of efficiency due specifically to alcohol are given in terms of percentages.

The loss of efficiency due to alcohol is universal and pronounced among the functions tested, with the exception of the rise in pulse rate. Coördination of motor control and speed of tapping are appreciably reduced, steadiness is more markedly disturbed. For all of these motor functions, the effect of the large dose is greater than that of the small. On mental efficiency, the drug has a similar disastrous effect, similarly proportionate to the size of the dose.

The singular rise in pulse rate, which was also observed by Dodge and Benedict, and also by Hull during the use of tobacco, is probably a symptom of the arousal of internal mechanisms to combat the damaging effects of the drug. In support of this hypothesis was the finding by Hollingworth, that those subjects whose mental and motor control were least influenced by the drug showed the greatest increase in pulse rate.

Other Drugs.—*Strychnine* in fairly large doses ($1/15$ to $3/15$ grains) seems to lead to a temporary increase in ability to run a complex machine (dotting machine) and in capacity to memorize, often followed by a decrease to less than normal capacity unless the dose is repeated. Very small doses, $1/30$ to $1/20$ grain (according to Poffenberger), produce negligible results on speed of tapping, aiming, and a wide variety of mental functions. *Opium* and *morphine* appear to cause an initial stimulation which appears slowly and rises to a maximum, and then efficiency descends below, sometimes considerably below,

normal. *Cocaine* causes a large immediate stimulation followed by a period of pronounced depression. Because of its immediately stimulating effects it has become a great favorite among drug addicts.

Conclusions.

The experiments here given disclose only the immediate effects of external conditions, work and drugs. It would be unsafe to conclude that influences showing great immediate effects upon mental efficiency and skill would have a corresponding serious effect upon general health or upon particular bodily functions and organs when used continuously. It would be likewise unsafe to conclude that influences whose immediate effects are slight or zero would produce, when continuously used, no general or specific ill results. To determine the outcome of the habitual use of drugs or of habitual exposure to unusual environmental conditions constitutes another and more difficult problem. Of no mean importance, however, is the finding that not unusual doses of alcohol, caffeine, strychnine, and other drugs disturb mental and motor efficiency at once and more profoundly than deprivations of food or sleep, or exposure to natural extremes of atmospheric conditions, or to visual and auditory distractions, or continuous mental work. These substances richly deserve their name—"powerful drugs."

In the course of normal life, efficiency in mental work fluctuates not mainly because of the intrinsic effects of tea, wine, tobacco, fatigue, noise, or bodily conditions, but because of variations in motivation. The depressing effects of tobacco or moderate doses of alcohol are small compared to decreases in efficiency produced by relaxation of effort; the stimulating effects of brilliant light or coffee are slight compared to the increase in achievement

resulting from effective incentives. By dint of strong urges to succeed, the effects of excessive fatigue, loss of sleep, deprivations of food and bodily discomfort upon mental efficiency may be almost, if not wholly, swept aside. It does not follow that such practices should be followed without good cause. Excessive effort in such emergencies doubtless activates the sympathetic system and internal glands described in Chapter VII. In the long run, keeping productivity at the maximum under unfavorable conditions may lead to disastrous results. That few conditions, with exception of certain drugs, can keep us from rising to maximum achievements, at least temporarily when we will, is a notable possibility that need not be misused. Equally notable is the fact that, apparently, in normal daily life our productivity is appreciable less than it might be; it may be greatly increased by proper incentives. What is more important, it may be brought to higher levels and there habituated by well motivated and wisely directed practice, eventually to work as smoothly and with as little effort as at levels which are mediocre.

QUESTIONS AND EXERCISES

1. Arguing from analogy with facts presented in the chapter, what are the probable effects upon mental efficiency of: (a) headache, (b) "feeling out of sorts," (c) despondency, (d) indigestion, (e) toothache. Would the effects of these conditions vary with the effort one makes to work or would they have the same effect whether one tries to achieve or not?
2. Does it follow from what was said about the rôle of motivation that one should attempt to work himself up to a pitch of intense or exciting effort during everyday work? If you think so, does it appear that there are inconsistencies between views presented in the present chapter and those presented in Chapter VII?
3. If too much zeal, effort or distraction results in activating the

autonomic system, would continuous work under such conditions be advisable?

4. Are there any dangers to be encountered in the continual use of incentives aside from possible physiological effects?
5. What, in general, are the best forms of motivation, or, to put it another way, what is the best state of mind for efficient daily work?
6. From the studies of variations in efficiency during the day, what hours are probably the best for important tests in typewriting, playing the piano, pole vaulting, history, sending telegraph messages?
7. Explain the assumption that in the case of the habitual smoker, deprivation of smoking might have, irrespective of the physiological effect of the drug, a deleterious influence on efficiency.
8. Judging from statements made in the text, is it likely that we are very good judges of when we are highly efficient and when we are not? Mainly, what are the criteria by means of which we judge our efficiency?
9. Collect the opinions of ten people of your acquaintance concerning the effect of caffeine on efficiency. What reasons do they give for their views? Contrast such evidence with the conclusions drawn from scientific experimentation.
10. What are the real reasons why good ventilation is important? The false reasons?
11. Give illustration from your own experience of (a) a situation where feelings of fatigue preceded loss of efficiency; (b) a situation where loss of efficiency preceded feelings of fatigue; (c) a situation where the decrease of worry and excitement increased mental ability; (d) a situation where the elimination of unnecessary muscular fatigue made an increased amount of mental work possible.
12. At what time of the day do you think you can perform mental work most efficiently? Plan in detail an experiment to test this opinion. What precautions would it be necessary to observe?
13. Do the experiments on temperature and humidity have any bearing on the problem of the difference found between races living near the equator and races living nearer to the poles?
14. Diagram roughly what happens in a nervous system when an individual learns to disregard a distracting stimulus. (See Chapter X.)

GENERAL REFERENCES

General summaries of facts similar to those presented in this chapter will be found in: H. L. Hollingworth and A. T. Poffenberger, *Applied Psychology,* New York: D. Appleton, 1917, chapters 6 to 9 inclusive. J. B. Watson, *Psychology,* New York: D. Appleton, 1919, chapter 10. B. C Ewers, *Applied Psychology,* New York: Macmillan, 1923, chapter 22.

REFERENCES TO STUDIES UTILIZED IN THE TEXT

F. B. Knight and H. H. Remmers, "Fluctuations in Mental Production When Motivation Is the Main Variable," *Journal of Applied Psychology,* Sept., 1923.

H. D. Kitson, "A Study of the Output of Workers Under a Particular Wage Stimulus," *Univ. Journal of Business,* Nov., 1922.

W. F. Book and L. Norvell, "The Will to Learn," *Pedagogical Seminary,* Dec., 1922.

F. H. Allport, *Social Psychology,* Boston: Houghton Mifflin, 1924, chapter 11.

G. S. Gates and L. O. Rissland, "The Effect of Encouragement and Discouragement upon Performance," *Journal of Educational Psychology,* 1923, pp. 21-26.

G. S. Gates, "The Effect of an Audience upon Performance," *Journal of Abnormal and Social Psychology,* Jan., 1924.

E. L. Thorndike, W. A. McCall and J. C. Chapman, *Ventilation in Relation to Mental Work,* New York: Teachers College, 1916.

L. I. Stecher, *The Effects of Humidity on Nervousness and on General Efficiency,* New York: Columbia Univ. Archives of Psychology, 1916.

S. L. Pressey, "The Influence of Color upon Mental and Motor Efficiency," *Amer. Journal Psychology,* 1921, p. 326.

J. B. Morgan, *The Overcoming of Distraction and Other Resistances,* New York: Columbia Univ. Archives of Psychology, 1916.

A. I. Gates, *Variations in Efficiency During the Day,* University of California, Publ. 1916, and *Diurnal Variations in Memory and Association, loc. cit.,* 1916.

E. L. Thorndike, "The Curve of Work and the Curve of Satisfyingness," *Journal Applied Psychology,* 1917, p. 265.

T. Arai, *Mental Fatigue,* New York: Teachers College, 1912.

E. S. Robinson and F. Richardson-Robinson, "Effects of Loss of Sleep," *Journal Experimental Psychology,* 1922, pp. 93-100.

H. S. Langfeld, *On the Psychophysiology of a Prolonged Fast,* Princeton, N. J.: Psychological Review Co., 1914.

H. L. Hollingworth, *The Influence of Caffeine on Mental and Motor Efficiency,* New York: Columbia Univ. Archives of Psychology, 1912.

C. L. Hull, Part III, of *Tobacco and Mental Efficiency,* edited by M. V. O'Shea, New York: Macmillan, 1923.

W. A. R. Rivers, *The Influence of Alcohol and Other Drugs on Fatigue.* The Croonian Lectures delivered at the Royal College of Physicians in 1906, London: Arnold, 1908.

R. Dodge and F. G. Benedict, *Psychological Effects of Alcohol,* Washington, D. C., Carnegie Institute of Washington, 1915.

H. L. Hollingworth, "The Influence of Alcohol," *Journal Abnormal Psychology and Social Psychology,* Oct., 1923, and Jan., 1924.

A. T. Poffenberger, "The Effects of Strychnine on Mental and Motor Efficiency," *Amer. Journ. Psychology,* Jan., 1914.

CHAPTER XVII

THE NATURE OF INDIVIDUAL DIFFERENCES

A field of research in psychology which has developed with unusual rapidity, yielding facts that have been practically applied in a most extensive and useful way, is concerned with individual differences. The discoveries of the nature and significance of variations among individuals, the invention and improvements of instruments of measurement, the development of statistical devices needed to handle the results, and the use of the results in assisting human adjustments in many phases of life have been mainly the results of research conducted during the last twenty-five years. At the present time, the accumulated facts and experiences are sufficient to establish unquestionably the permanent value of the applications of differential psychology. To some of the facts and practices in this phase of psychology, the next three chapters will be mainly devoted. In the present one will be considered some of the general characteristics of individual differences and their causes.

Individuals of the same age differ greatly in every trait that has been measured or estimated. In height, weight, and strength; in susceptibility to disease, nervous stability and mental balance; in intellect, character, and skill; and in aptitudes for special subjects, arithmetic, spelling, music or athletics individual variations are found. These facts have been implicitly assumed in the discussions of the preceding sections; in the present chapter they will be treated with more precision.

The differences between members of the human species are quantitative. People are qualitatively the same in the sense that they have in some degree the same instincts, emotions, and capacities to learn, to perceive, remember, imagine, reason, and to be satisfied and annoyed. The physicists who have analyzed the "qualities" of tones of the human voice, of the violin, and of other instruments, find that the most subtle variations are due to the quantities of many constituent tonal elements which have been identified and measured. So with human traits, final analysis will probably show all variations to be due to quantitative combinations of specific abilities, which sooner or later may be discerned and measured. A human trait, such as initiative, vivacity or trustworthiness is, in the case of each individual, a composite of many kinds of abilities each present in a definite amount.

Average of the Two Best and Two Poorest Scores Found among 50 Children, Age 11, Approximately, in a New York School

	Best	*Poorest*
Reading, words per minute	242	126
Reading, value of hardest passage comprehended	30	12
Word knowledge, score	80	32
Spelling, number of words correct	95	33
Arithmetic, number of problems right	26	11
Writing, letters per minute	84	31

The Amount and Character of Individual Differences.

An idea of the range of ability found among individuals of the same age and the same general home and school environment is indicated in the accompanying table which shows the average of the two best and the two poorest scores, in each function, found among 50

children of approximately the same age in a New York school.

The most rapid readers cover nearly twice as much material per minute as the slowest; the best in word knowledge attain scores over twice as high as the poorest; the best in spelling correctly spell three times as many words as the poorest, and similar differences exist between the extremes in other abilities. The variations among the pupils in the same school grade in the average school are nearly as great.

These are merely statements of the differences between the best and poorest. The nature of individual differences in general are disclosed only by taking into account all the members of a group. For convenience in presentation we shall take at first a small group of children of the same age and observe the character of the differences in a single trait. In the accompanying table are the scores in a reading test obtained by 24 children, age 11 years.

Number of Paragraphs Read	*Pupils* (Each letter represents one pupil)
13	C
12	HJ
11	BM
10	I
9	AGN
8	DFQSU
7	BLVW
6	E
5	KPT
4	X
3	O

When the data are summarized as in the table below, we have a *table of frequency* or a *frequency distribution,* in which the scores are listed in the first column and the number of individuals receiving each score in the second column.

Number of Paragraphs	*Number of Individuals*
13	1
12	2
11	2
10	1
9	3
8	5
7	4
6	1
5	3
4	1
3	1

The distribution of abilities may be displayed graphically in a *frequency surface* or *surface of frequency,* in which the scores are represented along the base line and

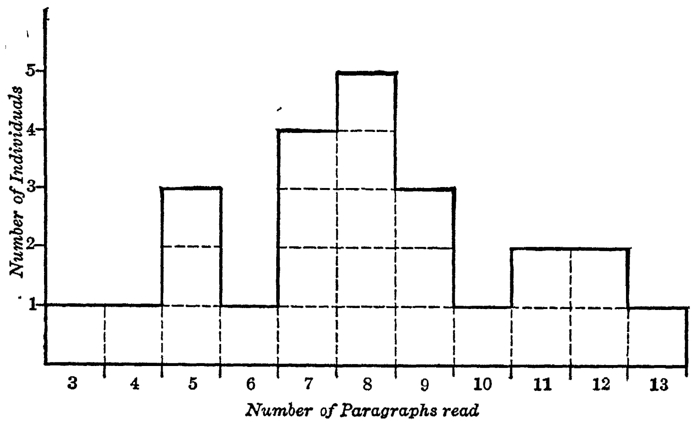


FIG. 54.—A FREQUENCY POLYGON BASED ON THE DATA OF THE TABLE ABOVE. The horizontal line shows the scores in the test; the vertical column at the left gives the number of individuals, *i.e.*, the frequency. Each individual is represented by a block. Usually the dotted lines are omitted since the number of individuals in the column above each score can be easily determined by a glance at the figures on the left.

each individual is represented by a block placed above the score, as in Figure 54. In usual practice, the separate blocks are not indicated; only the outline of the surface

is drawn. Such a surface is called a *frequency polygon.* When the mid-points of the tops of the rectangles are joined, as in Figure 55, the figure is called a *frequency curve.* Frequency surfaces and curves are used merely to give a more comprehensive picture of the form of distribution.

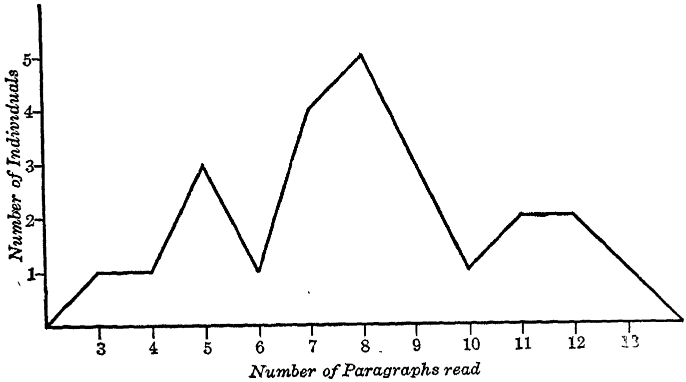


FIG. 55.—A FREQUENCY CURVE, CONSTRUCTED BY JOINING THE MID-POINTS OF THE COLUMNS OF FIG. 54.

In the distribution of abilities in this small group are found rough illustrations of the main facts concerning individual differences of individuals who are of approximately the same age and circumstances, namely:

1. The variations among individuals are wide.
2. The variations are continuous from one extreme to the other.
3. The individuals are clustered around a central or average ability rather than at the extremes.

Better pictures of the general features of individual variations are secured by taking larger groups of individuals of the same age. In Figures 56, 57, and 58 are given surfaces of frequency for different traits. The

curves are all similar. The variations are great; people are not divided into discrete groups of tall, medium and

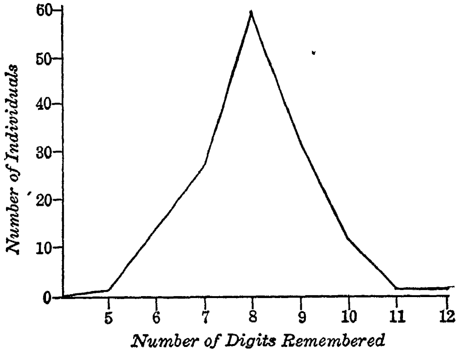


FIG. 56.—DISTRIBUTION OF ABILITY TO REMEMBER SERIES OF DIGITS SHOWN AT THE RATE OF ONE DIGIT PER SECOND. The horizontal line shows the length of the longest series remembered. The vertical line shows the number of individuals of each ability. Based on 165 college students.

short, of bright, average and dull, but on the contrary form a continuous series, between sparsely occupied ex-

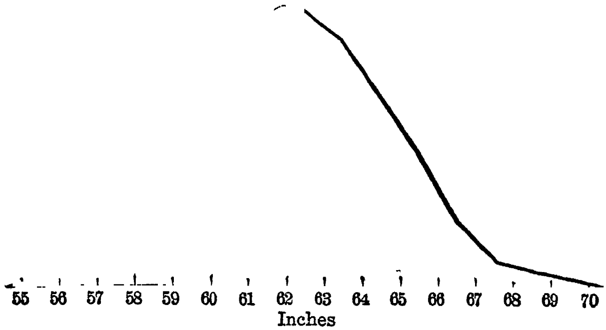


FIG. 57.—DISTRIBUTION OF THE HEIGHTS OF 1052 WOMEN. (From Starch, *Educational Psychology*, p. 31.)

tremes, with the largest number assembled near the middle. The most numerous individuals are those pos-

sessing average ability, and as abilities become greater or less, the number of individuals who possess such skill becomes smaller.

The Normal Curve of Distribution.

By first examining Figures 54 and 55 and later Figures 56, 57 and 58, it may be observed that the surface of

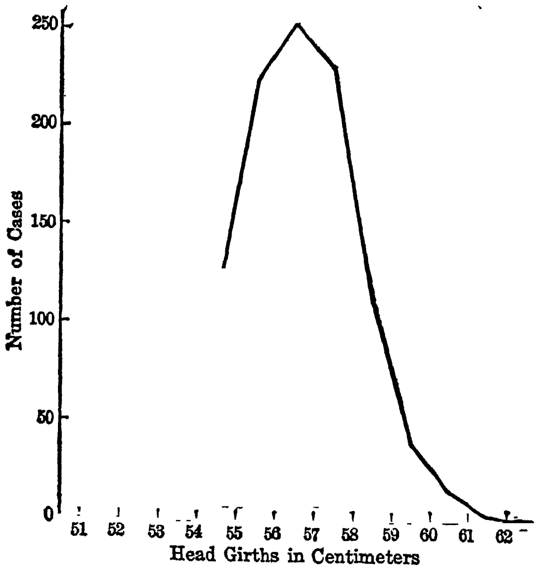


Fig. 58.—Distribution of the Head Girths of 1071 Boys, 16—19 Years of Age. (From Starch, *op. cit.*, p 31.)

frequency is very irregular in the former, in which small numbers of individuals are represented, and much more smooth in the latter, which embrace larger numbers. What would be the shape of the frequency surface if an infinite or, let us say, 100,000,000 cases were included? This, of course, has never been determined but there is good reason to believe that such a surface could be pre-

dicted on the basis of the data now on hand and that it would be essentially equivalent to the theoretical distribution of chance events.

If ten pennies, placed in a box, are shaken up, dumped out and the number of heads counted and recorded, and the same procedure repeated, we get a table of distribu-

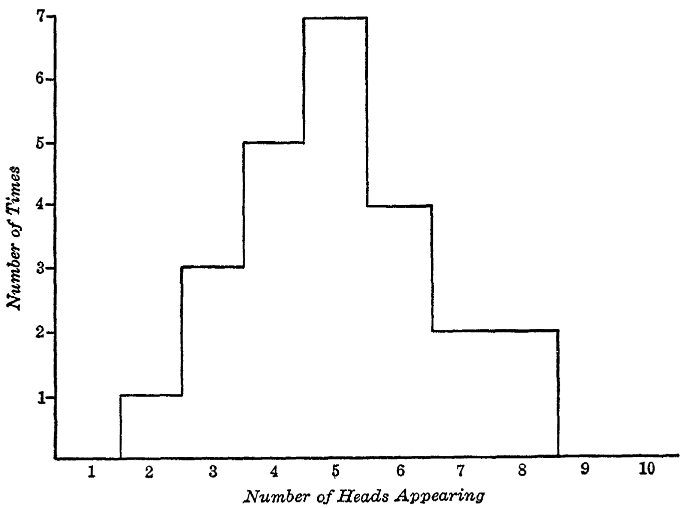


FIG. 59.—DISTRIBUTION OF THE NUMBER OF "HEADS" APPEARING IN 24 THROWS OF 10 PENNIES. Compare this figure, obtained by chance, with the distributions of 24 pupils shown in Fig. 55.

tion of the number of heads appearing. The results of twenty-four actual throws are shown in Figure 59. This figure affords an interesting comparison with Figure 55, based on the records of twenty-four pupils in a reading test. Both curves show continuous variation, a clustering about the middle and not greatly differing irregularities of profile. For ten pennies tossed 1000 times, the distribution of heads is shown in Figure 60. Compare this curve with those of Figures 57 and 58, which were based

upon measurements of about 1000 people. They are quite similar, and all are more smooth and symmetrical than

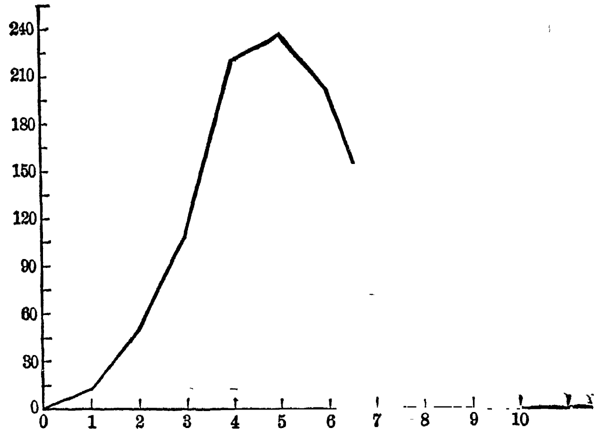


FIG. 60.—DISTRIBUTION OF THE NUMBER OF "HEADS" APPEARING IN 1000 TOSSES OF 10 PENNIES. Compare with Figures 57 and 58. (From Starch, *op. cit.*, p. 32.)

the curves based on the smaller number of cases. Mathematicians without actually having tossed an infinite num-

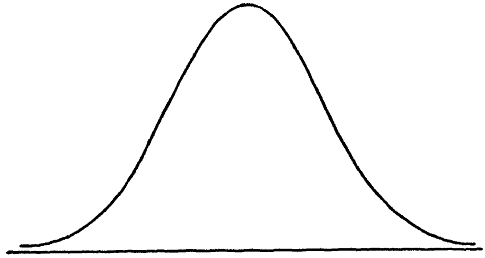


FIG. 61.—THE THEORETICAL PROBABILITY CURVE OR THE "NORMAL CURVE OF CHANCE."

ber of pennies have computed what the distribution would be. It is given in Figure 61 and is known by various names, such as the *theoretical probability curve*

(*or surface*), or the *normal curve of distribution,* or the *curve of chance.* Since the surfaces of distribution for human traits parallel closely the distributions of chance events in smaller numbers, it seems safe to assume that an infinite number of measurements of people of a given age selected at random would produce a curve identical with the theoretical probability curve, which portrays the outcome of an infinite number of tossings of pennies or other chance events.

By a chance occurrence is meant not a happening without a cause but an event determined by a large number of independent causes. To account for each penny's position, head or tail, would require knowledge of a very large number of events happening in the box, in the air and on the table during the process of shaking and tossing. The position of each penny, nevertheless, is determined by definite causes, not by miracles.

The Causes of Individual Differences.

The implication of the preceding paragraph is that the differences among individuals in any given trait are due to the large number of causal factors which operate independently. To account for the position in the group of a particular individual it would be necessary to ascertain a great many different determining factors and to discover in what way and to what degree each had exercised its effect.

Individual differences spring from causes that may be considered under two broad headings:

1. The contributions of heredity or native endowment.
2. The contributions of environment, that is, of the physical and social surroundings, of education and experience.

Individual Differences Due to Heredity.—The inherited determiners of a human trait are numerous. If one's height, for example, could be measured in hundredths of an inch, we would find the total determined in part by the thickness of the scalp, the thickness of the top layer of the skull, the vertical length of the head, the length of many vertebra in the neck and back, the thickness of cartilages between them, and so on through a series of anatomical traits until the soles of the feet are reached. Each of these traits may be inherited more or less completely independently of the others. The character of growth, too, may depend upon the inherited capacity of various glands which affect digestion, assimilation and distribution of materials, upon inherited dispositions to resist disease, fatigue and undernourishment. The number of inherited traits which may to some extent determine an individual's height at any time is probably legion. To disentangle and weigh them is a task which has been barely begun. Doubtless many factors have not as yet been discovered and of those which have been identified the specific effects are but roughly known.

All that is inherited, strictly speaking, is inherent in the germ cells from which the individual develops. But each character in the germ cell, the development of which may exercise effects on many traits is determined in part by various influences. In part, it is determined by the individual's sex, in part by race and by particular ancestors from the parents back through unnumbered generations. In the case of height, men are on the average taller than women, some races are taller than others, and among members of the same sex and race, some families are taller than others. Each and every one of our ancestors contributes in some degree to the amount of any traits we possess. The eminent Sir Francis Galton found that of

one's native endowment, on the average one-half is contributed by one's parents, one-fourth by the four grandparents, one-eighth by the eight great-grandparents, one-sixteenth by the sixteen great-great-grandparents, and so on back. What one's status in a particular trait will be, in so far as it is due to heredity, then, will depend upon a large number of independent causes. All of the factors which brought about all of the marriages in one's whole ancestral history must be included among the causes of one's status in traits which are to some degree inherited.

Inherited Traits Usually "Normally" Distributed.—Some traits are mainly due to heredity. The length of the nose, the circumference of the head, height and, as we shall see later, retentiveness, general intellectual capacity and perhaps other traits such as mental balance, susceptibility to emotional disturbances or tuberculosis. Where traits of these sorts have been measured in large representative groups of similar age and surroundings, the distributions usually approximate the normal curve. This must mean that the number of independent factors which enter into the heredity of peoples of the same age, sex and race is very large; so large and independent as to yield a distribution that approximates the arrangement of results mechanically produced by innumerable causes as in shaking dice. This being the case, it is customary to assume that where an inherited trait is at present unmeasurable, it varies in amounts among individuals in approximately the form of the bell-shaped curve unless evidence to the contrary is adduced. In other words, where a native trait, such as emotional susceptibility, or the native capacities involved in mechanical work, has not been measured and is not known to have been modified in some constant way in a group of the same age, sex and race, the most probable prediction—the best guess—

is that the trait is distributed in approximately the form of the normal curve among these people.

The Influence of Environment on Individual Differences.—Under environment are included all factors in living experience which may affect in any way any human traits. Accidents, deprivations and disease; foods, poisons and stimulants; habits, good or bad; home conditions, school conditions, companions, teachers, books, religion, social institutions, customs, incentives, punishments and other phases of experience are to be included. Some traits such as the color of the eyes, height and retentiveness are not greatly influenced by any save very unusual environmental factors; others like the color of the skin, knowledge of historical facts or interest in music are more greatly influenced by surroundings, training and other events or circumstances of life. The traditional question as to which is more potent in determining what one is and does, heredity or environment, cannot be answered intelligibly in general; it must be answered specifically for each of the innumerable human traits. The effect of environment varies from very little to very great. At present, our interest is in the nature of the effects of living, whether great or small, upon the character of individual difference in a group of people.

In almost any trait, the number of scars on the body, ability to read or speed of running a hundred yards and other traits upon which environment may have some influence, changes may be produced by a great many unrelated causes. The number of unrelated events and circumstances which may add to the number of scars on one's skin are simply legion. Suppose it were possible to collect a thousand boys of the same age and the same native capacity for learning. They would surely differ in reading ability and these differences would be caused

largely by environmental factors. The number of environmental influences would be enormous; poverty and wealth, health and strength, encouragement by parents, influence of chums, distance and quality of school, skill and interest of teachers, presence of books at home and school, and so on to an almost endless list of factors which would vary in degrees among the thousand children. In a word, the influence of environment in this case is the influence of an enormous number of more or less independent factors, just as in the case of coins shaken in a box, or of ancestral factors concerned in heredity. This being the case, in so far as the traits of individuals result from environmental factors of these numerous kinds, the traits will tend to be distributed in a group of individuals according to the normal probability curve. Thus the number of scars on the bodies of a thousand individuals of the same age, or the reading ability of those of the same age and native aptitude would be expected to approximate the normal curve.

Both heredity and environment, then, in the main, tend toward the production of individual differences distributed according to normal probability, as outlined by the bell-shaped curve of chance. Where traits are determined in some degree by both, which is the usual case, the result is merely an enlargement of the number of causes and consequently no lessening of tendency toward the "normal" distribution. This does not mean that any limited group of the same age, sex and race will be so distributed. For example, if we took not a representative sampling of all ten year old American boys but only the 10 per cent most apt in reading, the distribution for reading ability might not be "normal." If the biggest American soldiers were sent to battle first and were killed, the distribution of heights among American soldiers re-

maining would not be normal. Furthermore, if only those boys of age ten who were natively most gifted were taught reading and the others given no training, the distribution of the whole group would probably not be normal. Thus by limiting the character of individuals in a group or by differentiating in some constant way the influence of environment, the form of the distribution of abilities may be changed from the "chance" distribution. In the groups we are likely to find available under ordinary conditions, one or more factors of selection or one or more constant environmental condition may have been at work. It is, therefore, advisable to ascertain by experiment what the form of distribution is in typical groups, such as the third grade in school, college seniors, nurses, physicians.

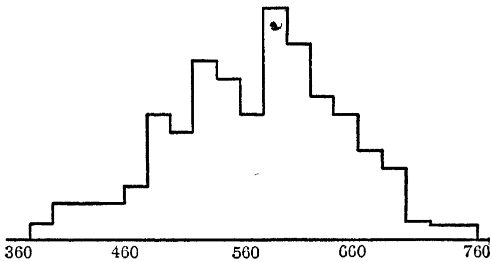


FIG. 62.—FREQUENCY POLYGON SHOWING ABILITY OF 254 PUPILS OF GRADE VI IN EDUCATIONAL TESTS. (From Kruse, *The Overlapping of Abilities in Certain Grades*, p. 41.)

THE DISTRIBUTION OF CERTAIN ABILITIES IN SELECT GROUPS.

Distribution of Abilities in School and College Classes.—School and college classes are groupings that have been more frequently and fully measured, probably, than any others. It is found that a large sampling of pupils in the same school grade usually approximates roughly the normal curve of distribution in

mental ability and scholastic achievement. A sample is given in Figure 62. This is not a perfect bell-shaped curve, but it approximates the normal curve more closely than curves with two peaks and a deep valley between, or curves with most individuals clustered at one or the other extreme. If a million pupils of the same grade, instead of but 254 as in this grade, were measured, the approximation to the normal curve would be closer, in all likelihood. In Figure 63 the frequency surfaces for

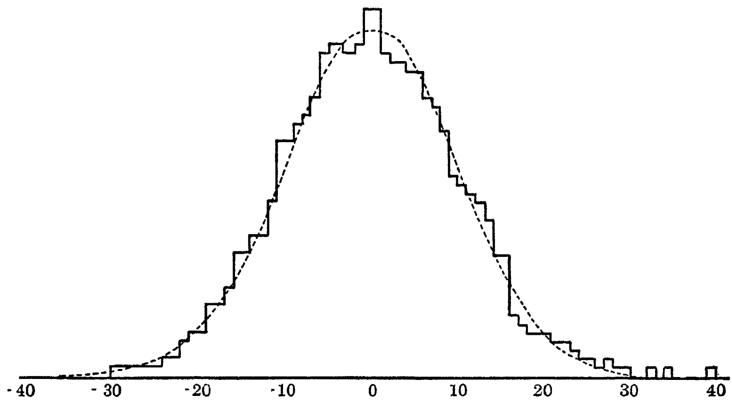


FIG. 63.—DISTRIBUTION OF SCORES IN A TEST OF MENTAL ABILITIES OF 1656 PUPILS IN GRADE IX. The broken line is the theoretical probability curve. It fits the real distribution fairly closely. (From E. L. Thorndike, *Journal of Educational Research*, Nov., 1924.)

the scores of 1656 pupils in grade 9 in a group of mental functions are shown, with the probability curve superimposed. The surface is an approximation to the bell-shaped probability curve. For this, the reason must be that the abilities represented are the products of very large numbers of causes more or less independent. That abilities in such groups as these do tend to approximate the normal curve makes possible a number of practices of considerable usefulness.

Some Properties of the Normal Curve.—The theoretical surface of frequency has a number of mathematical properties that may be utilized in dealing with groups in which an ability is distributed in approximately the form of that surface. Most of these properties are too technical for description here, but one sample may be given.

If we cut off from the tips of each end of the theoretical curve (Figure 61) a small area, such that 99.6 per cent of

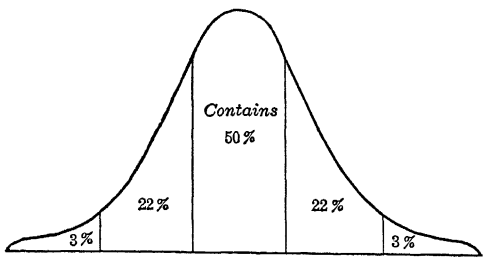


FIG. 64.—THE BASE LINE OF THE THEORETICAL PROBABILITY CURVE HAS BEEN DIVIDED INTO FIVE EQUAL PARTS AND VERTICAL LINES HAVE BEEN ERECTED AT THE DIVIDING POINTS GIVING FIVE AREAS. The percentage of the whole population which each area includes is indicated.

the whole area remains (since in the theoretical curve the sloping curves actually meet the base line only at infinity) and divide the remaining base line into five equal parts, between which vertical lines are erected, the areas (as shown in Figure 64) from left to right will contain the following percentages of the whole: 3, 22, 50, 22, 3. If the abilities of a group of individuals conform to this surface, the percentage of the whole number found in these areas would be the percentages found in the several sections of the normal curve. Since achievements of groups of children in a given grade or students in a given class in college tend to approximate the normal curve, the figures afford a theoretical basis for the assignment of final class marks.

Applying Properties of the Normal Curve to the Grading of Students.—This plan, and certain reasons for it, are illustrated by the results of study of the grading system in a state university of the middle west. Samples of the distributions of grades before the plan was adopted are shown in the following table.

PERCENTAGE OF STUDENTS GIVEN VARIOUS GRADES
(From Max Meyer)

Course	*Highest Grade* A	*Next* B	*Next* C	*Lowest Grade* F	*Total Number of Students*
Philosophy.......	55	33	10	2	623
Economics.......	39	37	19	5	161
German II......	26	38	25	11	941
Mechanics.......	18	26	42	14	495
English II.......	9	28	35	28	1098
Chemistry III....	1	11	60	28	1903

Of the students taking Philosophy 55 per cent received "A's" and but 2 per cent "F's"; of those taking Chemistry, 1 per cent received "A's" and 28 per cent "F's," while the proportions for other courses are distributed between these extremes. Recent work in testing more extensively the abilities of students in college departments makes it quite certain that such assignments of grades are not fairly representative of the variations in the abilities of students electing the several courses. The real achievements within each group approximate more closely the distributions found in the normal probability curve and consequently the grades should approximate those percentages more closely.

Soon after the irregularities in grading were revealed, the university adopted a scheme of assigning marks which embraced the five divisions and percentages as given in

Figure 64. The approximations to this ideal classification during one semester were as follows: Excellent, 3.9 per cent; superior, 19.7 per cent; medium, 51.0 per cent; inferior, 16.8 per cent, and failure, 8.5 per cent.

The plan of grading in accordance with the normal curve of distribution should not be applied too rigidly especially to small classes. The smaller the class, in general, the greater the deviations of ability are likely to be. Some courses, moreover, may attract superior students. In general, however, grades should correspond fairly closely to the normal distribution in the long run unless good reasons for exceptions are known.

Statistical Methods.

With the variations among individuals in a group as great as they are, many difficulties have been encountered in dealing mathematically with data, such as scores in intelligence tests, involving a whole group or several groups. These difficulties have been greatly allayed by the development of statistical methods,—methods of reducing quantitative statements for all the members of a group to some single mathematical formula. Into those devices we shall not enter except to illustrate the meaning of *a coefficient of correlation,*—a statistical expression we shall need to know in order to understand several facts to be presented in the next two chapters.

The Coefficient of Correlation.—In many psychological investigations it is desirable to ascertain the association or correlation of two traits within a group of individuals. We may desire, for example, to discover how speed of learning and retentiveness are associated: Do the persons who learn rapidly retain better, worse, or about the same as those who learn slowly? Or, we may

desire to ascertain the degree to which height is associated with intelligence; how abilities in mathematics correspond to abilities of the same students in history, and so on. What we want, in these cases, is a simple expression of the general association of these two abilities within a whole group. *The coefficient of correlation,* whose symbol is *r,* is a statistical device for securing a statement of such an association.

We shall give here no detailed account of the methods by which the coefficient of correlation is computed but merely a simple illustration of its significance. In the series of columns below, suppose that the first numbers of each pair represent the ranks of ten different pupils, A, B, C, etc., in the rate of learning. The most rapid learner is given rank 1, the next rank 2, and so on to the lowest indicated by 10. In the second column of the pair, the rank of the same pupil (A or B or C, etc.) in retentiveness is given. The *coefficient of correlation* is a

Illustrating the Significance of Coefficients of Correlation (r) of Various Magnitudes

Pupils	I		II		III		IV		V	
	Rank in Trait X	*Rank in Trait* Y	*Rank in Trait* X	*Rank in Trait* Y	*Rank in Trait* X	*Rank in Trait* Y	*Rank in Trait* X	*Rank in Trait* Y	*Rank in Trait* X	*Rank in Trait* Y
A....	1	1	1	3	1	3	1	5	1	10
B....	2	2	2	1	2	5	2	6	2	7
C....	3	3	3	2	3	7	3	2	3	8
D....	4	4	4	5	4	1	4	7	4	5
E....	5	5	5	6	5	8	5	8	5	9
F....	6	6	6	4	6	2	6	10	6	3
G....	7	7	7	8	7	6	7	1	7	1
H....	8	8	8	7	8	4	8	4	8	2
I.....	9	9	9	10	9	10	9	9	9	4
J.....	10	10	10	9	10	9	10	3	10	6
	$r. = +1.00$		$r. = +0.90$		$r. = +0.51$		$r. =$ 0.00		$r. = -0.63$	

single statement of the central tendency of relations between abilities indicated in the two columns.

In sample I there is a perfect positive correlation between abilities in the two traits, X and Y, which means that each pupil has in one trait the same relative ability that he has in the other. Perfect correlation which is indicated by $r. = +1.00$ is extremely rare among human traits. In the second sample, the coefficient is $+0.91$, a very high positive correlation which allows, however, for some shifting of positions. Pupil A, best in trait X, is third in Y; Pupil B, second in X, is first in Y, and so on. The third sample, $r. = +0.51$, is a substantial but not very high positive correlation; its meaning will be best understood by examining the data of the columns. In IV, the correlation is zero, the result that is approximated when the arrangement is left entirely to chance, as would be the case, for example, if the positions under X and Y were determined by drawing the numbers from a hat. From zero to minus 1.00 is a range of negative correlations, in which the ranks in one trait are the reverse, in various degrees, of those in the other. Sample V, in which $r. = -0.63$, illustrates a fairly high negative correlation.

QUESTIONS AND EXERCISES

1. Can you think of any trait in which people are not different? Any in which there are more people at the extremes than in the middle?
2. In the light of facts presented in the chapter would you recommend that school children be grouped and promoted according to chronological age primarily?
3. It has been proposed, inasmuch as individual differences in achievement in college courses are so great, that a scheme of "credit for quality" be adopted. For example, those getting A

receive 5 points, B 4, C 3, D 2, and F, 0. Defend or oppose such a plan or, better still, propose a superior one.

4. In physical recreation in college, should all students be given the same amount and type of exercise?
5. In view of the nature of individual differences, would you favor the plan of giving all carpenters the same wage per hour? What other factors might merit consideration.
6. Criticise or defend each of the following practices:
   a Insisting on a long march that all keep step.
   b Organizing companies in the army to get together those of as nearly equal height as possible instead of having a range of heights in each company.
   c Assigning all students the same length of time to master an assignment.
   d Dividing large college classes into several sections according to their general scholastic ability in the subject in question.
   e Having the brighter students in this course do fewer exercises than the duller.
   f Having a fixed rule in college that all full-time students must take 16 points; no more, nor less.
   g Having a rule that anyone who passes all examinations gets credit for the course without regard to attendance.
   h Assuming in industry or business that a man who succeeds in one job will also succeed in others.
7. Do the facts of individual differences favor mass or individual instruction in schools and colleges?
8. Draw up a list of at least 30 factors, classified under two headings which contribute to one's ability to play cards.
9. Make a list of ten problems which might be solved by the use of the coefficient of correlation.
10. Place strips of paper bearing the numbers from one to ten in a box. Draw them out one at a time and record the order. Do it again and observe the resemblance between the two orders. Is it most like I, II, III, IV or V, on page 519. Try the same thing a number of times. If you did it a sufficient number of times, which order, on the average, would be most closely approximated?
11. Criticise or defend the method of assigning grades—3% A, 22% B, etc.—described in the chapter. Under what conditions would the scheme be least appropriate?

GENERAL REFERENCES

E. L. Thorndike, *Educational Psychology,* Vol. III, New York: Teachers College, 1914; E. K. Strong, *Introductory Psychology for Teachers,* Baltimore: Warwick and York, 1919, pp. 98-180; H. O. Rugg, *A Primer of Graphics and Statistics,* Boston: Houghton Mifflin, 1925.

CHAPTER XVIII

INTELLIGENCE

In the preceding chapter it was stated that all so-called human "qualities" are really complexes or composites of particular abilities existing in definite amounts ranging from zero up. This applies to the human trait, intelligence, which will serve as an excellent example of both the theoretical value and the practical usefulness of the measurement of complex traits.

The fact that individuals differ in ability to learn, to adjust to novel situations and to manage things, people and ideas has been repeatedly observed throughout the course of recorded history. In the early stages of experimental psychology, efforts were made to measure more precisely some of the aspects of intelligence. In 1880, Ebbinghaus first succeeded in devising tests of ability to memorize various materials with sufficient accuracy to portray individual variations. Following this notable accomplishment, many types of single tests, such as the completion of sentences in which certain words were omitted, the completion of pictures, the speed of recognizing figures, words or sentences, the cancellation of letters from specified materials, arithmetical operations, association tests, etc., were suggested as possible touchstones of general intelligence. The search for a single test, guided by the belief that intelligence was a single unitary power that might disclose itself in clean-cut fashion in a single task or situation, inevitably led to but partial success.

It remained for Alfred Binet, a distinguished French psychologist, to conceive the idea that intelligence was not a single quality or power, but a complex of abilities. The effect of this belief was a radical change in the method of approach to the problem. Conceiving intelligence to be not homogeneous but possessing many aspects, Binet began a search for many types of performances or problems in which intelligent behavior should be displayed. Believing also that intelligence was largely native, although recognizing the fact that previous experience influences the results of most psychological tests, Binet began by searching for bits of information available to children in all walks of life, and for problems, puzzles, questions, mental tasks of various types that were not likely to be encountered under ordinary home or school conditions. The information sought, then, was of the sort that every child has ample opportunity to acquire, and the problems of a type that no child was likely to have previously learned to solve.

The Binet-Simon Tests.

After fifteen years of work, in part of which he was assisted by Theodore Simon, Binet published in 1908 the series of tests known as the *Binet-Simon Scale of Intelligence.* It consists of 59 individual tests which are arranged in an order of difficulty. The easiest may be passed by an average three-year-old child, the most difficult requires the ability of an average twelve year old.

Stimulated by this successful achievement, a large number of extensions and revisions of the scale have been made in many countries. In America the work has been specially active, and among the several revisions, that by Terman, known as the *Stanford Revision and Extension of the Binet-Simon Scale,* is most thorough. This scale

consists of 90 tests arranged, like the original, in order of difficulty from some that should be passed by a three-year-old child to others that demand "superior adult" ability.

What the scale actually measures may be explained more readily after an examination of some of the tests. In the group for age 3 are the following tasks:

Points to the nose, eyes, mouth, hair. To pass the test, the child must succeed in 3 of the 4 tasks.

Names familiar objects—key, penny, closed knife, watch, pencil. Subject must succeed in 3 of the 5 tests.

Enumerates at least 3 objects seen in 1 of 3 pictures displayed separately.

Gives sex, *i.e.*, boy or girl.

Gives last name.

Repeats sentence containing 6 or 7 syllables; *e.g.*, "The dog runs after the cat."

Repeats 3 digits, one success in 3 trials.

In the group for age 10 are the following:

Defines satisfactorily at least 30 words of a list of 50, ranged in order from easy to difficult. Words at about the 10-year level of difficulty are: bewail, priceless, disproportionate, tolerate, artless, depredation, lotus, frustrate. The hardest words in the list, which are mainly too difficult for the average adult, are: piscatorial, sudorific, parterre, shagreen, and complot.

Detects the "absurdity" in 4 out of 5 statements such as the following: "A man said: 'I know a road from my house to the city which is down hill all the way to the city and down hill all the way back home.'"

Copies from memory a geometrical figure previously studied for 10 seconds.

Gives satisfactory answers to 2 out of 3 questions such as the following: "What ought you to say when someone asks your opinion about a person you don't know very well?"

Must be able to say spontaneously at least 60 words—any words of which the subject can think—in a period of 3 minutes.

Among the 90 tests in the Stanford Revision of the Scale are many which measure the ability to manipulate mentally familiar facts, such as repeating digits forwards and backwards, counting backwards, visualizing changes of the hands of a clock; to reason out the solution of problems which utilize the facts of arithmetic, of physical relations, and of practical situations. In some tests, the knowledge of abstract facts and relations is demanded: *e.g.*, in defining such words as pity, revenge, charity, envy; in giving the similarities in three things, such as wool, cotton, leather; the differences between a President and a King or between poverty and misery; in grasping the thought contained in a short paragraph, or in giving the meaning of pictures or fables. In general, the Binet test seems to include a variety of tasks on which the mental abilities described in our previous chapters on learning, the acquisition of ideas, especially abstract ideas and reasoning or problem solving, depend. Indeed, these were precisely the aims of Binet and his followers. They attempted to secure tests of various abilities to learn, especially to learn complicated and abstract facts, and also to profit by experience in a general way. They tried to secure tests that would indicate native ability to adapt one's self to new situations, to see the problem, hold it in mind, and reason out the solution. In these tasks, it is assumed that mental alertness, keenness, quickness and breadth of grasp, as well as suppleness, accuracy, and control would be involved.

Performance Tests.

The Stanford-Binet is largely a verbal test; mainly the responses are made orally to questions or problems presented orally by the examiner. It cannot, therefore, be used successfully with deaf or foreign children or with

children having speech defects. For such cases, and for others who are clumsy in handling language, graded series of performance tests have been constructed along lines similar to those adopted by Binet. Of these, the most thoroughly standardized series is that of Pintner and Paterson. It includes fifteen tests, all of which require the management of concrete objects. In the "form board"

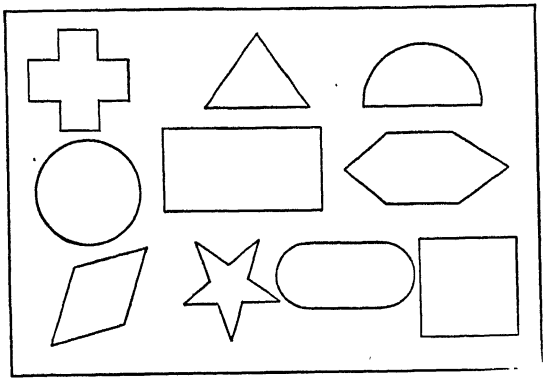


Fig. 65.—The Sequin-Goddard Form Board, One of the Easiest, Used With Children or Feebleminded Adults. Blocks to fit the holes shown in the above board, are placed before the subject in a prescribed arrangement. The score is based upon the time required and number of errors made in fitting the blocks into the holes.

test, for example, record is kept of the time and number of false moves made by a child in placing a number of blocks of different shapes in appropriate holes in a board. The Knox cube test illustrates another type of performance. Four small cubes are placed in a row before the child while the examiner holds a fifth with which, after securing the subject's attention, he taps the others in a prescribed order, such as 1, 2, 3, 4. The child, who has been given the cube, attempts to tap the other cubes in the same order. Various orders such as 1-2-3-4, 2-1-4-3, 1-3-2-4, etc., have been carefully standardized. A third

representative performance test is a "picture completion" in which the task consists in the insertion of cut-out portions to make a picture complete and intelligible.

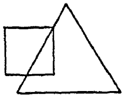
Group Tests.

Like the Binet Scale, the Pintner-Paterson series is an instrument of precision, carefully standardized, which must be given to subjects individually by trained examiners. To meet the demands for more extensive testing, various forms of group tests which may be administered by competent people without extensive training have been devised.

Group tests may be divided roughly into two types, the verbal and the non-verbal, although many include both types of material. Of the verbal tests, the most familiar is the "Army Alpha," devised by a group of American psychologists and applied to more than a million and a half men in the American Army during the Great War.

The Army Alpha test, given to recruits who could read and write, consists of 212 separate questions, exercises, or problems of eight general types, of which four are here illustrated.

The first group of tests comprised twelve tasks ranging from easy to hard, of the following type:

3. 

The examiner says: "Attention. Look at the square and triangle at 3. When I say 'Go,' make a cross in the space which is in the triangle but not in the square, and also make a figure 1 in the space which is in the triangle and in the square.—'Go!'" (Allow not over ten seconds.)

Test 2 consists of 20 arithmetic problems.

Test 3 consists of 16 "common sense" problems. The subject is to make the best answer. The easiest and most difficult are: (1) Cats are useful animals because—they catch mice; they are gentle; they are afraid of dogs. (16) Why is it colder nearer the poles than at the equator? Because—the poles are always farther from the sun; the sunshine falls obliquely at the poles; there is more ice at the poles.

Test 4 consists of 40 pairs of words, the two words of each pair being either synonyms or antonyms. The examinee is to underline *same* or *opposite* where appropriate. The first and last pairs are:

Wet—dry .... same—opposite
Encomium—eulogy .... same—opposite

There are many other verbal group tests, some especially designed for elementary schools, some for high schools, some for colleges, and others for use among clerical and other occupational groups. Non-verbal group examinations have been devised to test very young children, illiterates, and others who cannot read or write words. In some of these examinations directions are conveyed orally; in others by means of pantomime. A variety of tasks are provided, such as to draw a line to indicate the shortest path through a maze, to fill in the missing part of a picture, to strike out an irrelevant part, or to complete a series of marks begun according to a fixed plan. In each type of test, problems ranging from easy to hard are provided.

The various types of tests and scales are not exactly equivalent. They do not all measure identical abilities, although there is much in common among them. It will be advisable, therefore, to confine the discussion mainly to one test, the Stanford-Binet.

Mental Age and the Intelligence Quotient.

The Mental Age.—To make the subject's score on an intelligence test meaningful, a standard of comparison must be provided. The method adopted by Binet, and by many others later, was to use the average performances of individuals of different ages as a standard of comparison. Binet ascertained just what the average score achieved by a group of three-year-old children, four-year-old, etc., was. Of course, in such a procedure care must be exercised to get a sufficient number of representative children for each age: not merely a few bright ones or dull ones, but all kinds, picked at random, giving a distribution of ability approximating the normal surface of frequency. When this is done, it becomes possible to state a child's achievement in terms of the age at which the child of average ability would secure the same score. This score is called the "Mental Age" or the "M.A." for short. Thus, a particular child whose achievement in the test is equivalent to the Mental Age of ten years has the general mental ability of the average ten-year old; it matters not what the actual chronological age of the particular child may be.

The Mental Age, then, gives us a statement of the general mental ability of a subject *at the time of the test* in comparison with average children of different ages. If a ten-year-old child earns an M.A. of 10, he has *average* mental ability. If he earns an M.A. of eleven years he is obviously superior to the average; if he earns an M.A. of eight years, he is markedly inferior. The Mental Age is really a statement of a child's mental maturity at the time, and this implies, of course, that general mental ability grows or matures. There is, indeed, fairly substantial evidence that general mental

ability as measured by the Binet test grows gradually and about as uniformly as height to a maximum of maturity which is reached about the same time, *i.e.*, in the late teens. Terman has placed the average age of maturity at 16, although others have put the date at various points between 13.2 and 20. These are approximate statements of the average; particular individuals mature

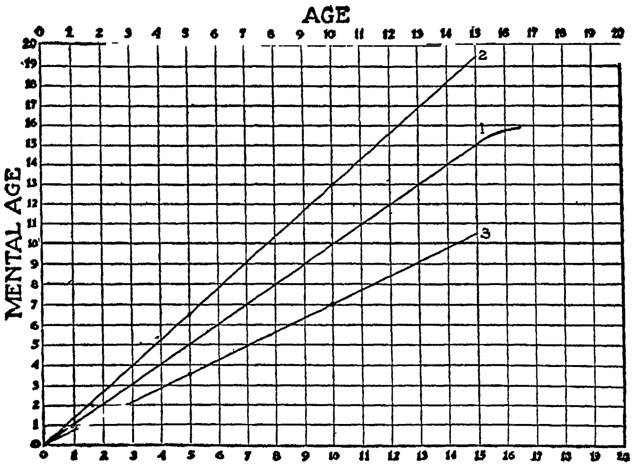


FIG. 66.—MENTAL GROWTH CURVES AS THEY WOULD BE IF THE I.Q. WERE CONSTANT. Number 1 is a mental growth curve as it would be if a child continued to test at 100 I.Q.; number 2 for a child who continued to test at 133 I.Q.; and 3 for a child at 67 I.Q. (From Terman's *Intelligence of School Children*, Copyright, 1919, published by Houghton Mifflin Company.)

mentally at different ages as they do physically. (See Figure 67.)

The Intelligence Quotient.—For practical purposes, we want to know more than merely the amount of general mental ability at the moment; we wish to know, if possible, how rapidly the child's mental ability will develop. We desire to be able to predict growth in mental ability;

to tell what it will be one, two, or more years hence. The device most commonly used for this purpose is the Intelligence Quotient, or the "I.Q." The Intelligence

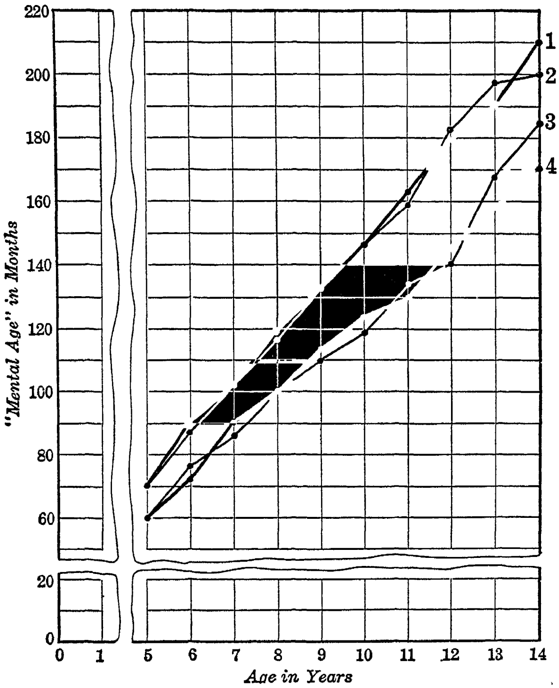


FIG. 67.—ACTUAL MENTAL GROWTH CURVES FOR FOUR GROUPS OF CHILDREN OBTAINED BY CONSECUTIVE ANNUAL MEASUREMENTS WITH THE STANFORD-BINET SCALE. Number 1 is a curve for bright boys; 2 for bright girls; 3 for less bright girls and 4 for less bright boys. Compare these actual curves with the hypothetical curves of Fig. 66. (From Baldwin and Stecher, *University of Iowa Studies,* Vol. II, No. 1.)

Quotient is obtained by dividing by the chronological age the mental age received on a test like the Stanford-Binet. For example: Pupil A has an M.A. of 10 years and a chronological age of 10 years. Divide M.A.10 by

C.A.10, the Intelligence Quotient is 1.00; Pupil B, whose chronological age is also 10, has an M.A. of 12; 12 divided by 10 gives an I.Q. of 1.20. Pupil C, also 10 years of age, earns an M.A. of 8, which divided by 10, gives an I.Q. of .80. Usually the decimal is disregarded; we say that A has an I.Q. of one hundred, B of one hundred twenty and C of eighty. The Intelligence Quotient is obviously a ratio—the ratio of the Mental Age to the Chronological Age.

The value of the Intelligence Quotient for purposes of prediction depends upon the fact that it is found to be—at least approximately—constant from year to year. This fact is ascertained by repeatedly testing, at intervals of a year or more, the same individuals with the same tests. Thus far, the Stanford, and to some extent other revisions of the Binet Scale, are the only ones that have been tried out in this way. A number of investigations have shown that the I.Q. on a retest at an interval of a year or more varies somewhat in particular cases, but on the average the change is 5 points or less. (See Figures 66 and 67.)

The Intelligence Quotient indicates, then—at least approximately—the rate of mental growth. An I.Q. of 100 means that the child probably has grown, is now growing, and will continue to grow in mental ability at the average rate. An I.Q. of 120 means a growth 20 per cent more rapid; an I.Q. of 75 means growth 25 per cent less rapid than the average. Since the I.Q. remains approximately constant from year to year, it expresses the relative brightness or dullness of an individual. Thus, irrespective of age, an I.Q. of 100 means average mental alertness, suppleness, breadth of grasp, and capacity to learn, whereas a higher I.Q. indicates superiority in these respects and a lower I.Q. inferiority.

Is General Intelligence Native or Acquired?

The Binet tests were devised to measure *native* mental aptitudes. What is the evidence that intellectual capacities are inherited and that they grow like height to a maturity which was essentially predetermined by conditions in the germ cells?

The approximate constancy of the Intelligence Quotient is one line of evidence. If intelligence were essentially modifiable, the variations in experience would, of course, cause corresponding variations in I.Q. But they do not. We find, on the one hand, children who have enjoyed exceptionally good care at home and school, remaining at approximately the same low I.Q. For example: "X is the son of unusually intelligent and well-educated parents. The home is everything one would expect of people of scholarly pursuits and cultivated tastes. . . . When brought for examination X was eight years old. He had twice attempted school work, but could accomplish nothing and was withdrawn. The Binet tests gave an I.Q. of approximately 75, that is the retardation amounted to about two years. The child was examined again three years later. At that time, after attending school two years, he had recently completed the first grade. This time the I.Q. was 73."

That school or other formal educational training does not greatly increase the I.Q. is shown by such cases as the following:

"Walter and Frank have been under observation for several years. Until the ages of five and seven years, they lived in an exceptionally poor home. . . . Both of the parents died within a year, and the boys were adopted by a woman of decidedly more than average ability, who treated them as her own sons. At the time of adoption,

one tested at 73 and the other at 82. Four years later the I.Q.'s were 70 and 77."

The writer secured the results of Binet tests from a group of 70 school children (Grades 3 to 6 inclusive) whose achievements in all of the representative school subjects were also carefully measured. During a period embracing nearly two school years, unusually intensive work in reading, spelling and arithmetic had been done with many pupils who were backward in these subjects. The improvements in scholastic attainments varied greatly among the subjects who were, near the end of the period, retested with the Binet Scale. Most of the pupils showed some change in I.Q., the greatest gain being 18 points, from which the changes varied to a loss of 12 points, with an average change of about 6 points. The important question was whether great gains in I.Q. were made by those whose advance in educational achievements had been greatest and whether losses in I.Q. occurred mainly among those who had made the least amount of scholastic progress. There was no association between the two tendencies; the correlation was zero. An increase in I.Q. was found as frequently among those whose achievements had been small or average, as among those whose progress had been great. Those whose educational progress had been great gained in I.Q. no more frequently than those whose gains were small or average.

From these instances, it appears that while the tests are still imperfect, they disclose quite clearly the fact that there are innate mental capacities, the growth of which is not greatly accelerated or retarded by intensive school training. The general tendency of the I.Q. to remain constant implies that, in the main, individuals are born and tend to remain at a level which is relatively

low, average, or high. This is the rule, although there are exceptions.

High, low, and average mental ability tends to run in families in much the same way as height, eye color, and other physical features. The inheritance of intelligence is most vividly illustrated in the lineage of extreme cases, of which the "Kallikak" family is a notorious example. Martin Kallikak, a youthful soldier in the American revolution, met a feeble-minded girl who bore him a son of low mentality. In 1912 there were four hundred and eighty known direct descendants of this union. Of these, one hundred and forty-three were of such low mentality as to be classified as feeble-minded, and most of the others were of relatively low mental ability. In addition, thirty-three of the latter were sexually immoral, thirty-six of illegitimate birth, and twenty-four confirmed alcoholics.

Contrast the dark picture of the Kallikaks with the accomplishments of the Edwards family. Of Jonathan Edwards, born in 1703, there were, in 1900, 1394 identified descendants of whom thirteen were college presidents, sixty-five college professors, sixty physicians, one hundred clergymen, seventy-five army or navy officers, sixty prominent authors, one hundred lawyers, thirty judges, eighty prominent public officials, and a great many successful bankers, business men, landowners, etc. None was known to be of feeble mentality, and none was known to have committed a crime, while many achieved great eminence in their profession.

The Significance of General Intelligence.

The implication of the preceding section is that general intelligence, provisionally defined as a composite measure of abilities to learn, to grasp broad and subtle

facts with alertness and accuracy, to exercise mental control, and display flexibility and sagacity in seeking the solution of problem-situations, is native—that is, it develops fairly steadily like height, reaches a maturity at some time in the teens, and sets for each individual a limit of achievement. These implications must be further tested.

We shall first indicate the form of distribution of the Intelligence Quotients, and then proceed to study the significance of the several levels. Generalizing from the measurements of groups of representative children, the distribution of intelligence would probably be about as given in the following table:

I.Q. below 70	1%
I.Q. 70–79	5%
I.Q. 80–89	14%
I.Q. 90–99	30%
I.Q. 100–109	30%
I.Q. 110–119	14%
I.Q. 120–129	5%
I.Q. over 130	1%

Intelligence and Scholastic Achievement.

Inferior Intelligence.—Intelligence Quotients of 20 or less are found infrequently. Persons with I.Q.'s in this range are "idiots," essentially incapable of learning. Individuals with I.Q.'s from 20 or 25 to 50 or so are ordinarily called "imbeciles" and all within this range are capable of but meagre learning and adaptability. In the range from 50 to 70 I.Q. are found various degrees of "feeble-mindedness," which grade quite imperceptibly into the less, but nevertheless seriously, dull individuals above. Throughout this enormous range, from approximately 0 to 70 I.Q., there is absolutely no doubt about

the innate limitations upon the acquisition of complex mental functions, and the rate of acquisition where learning is possible at all. It is almost invariably futile to attempt to teach children of I.Q.'s less than 50 to read, spell or do arithmetic. Genuine comprehension in reading or arithmetic can seldom be achieved even by those whose I.Q.'s fall between 50 and 60, and the little they do learn must be the result of arduous and prolonged application.

In the average case, an I.Q. of 75 is considered about the minimum essential for appreciable achievement in school work, but many with that degree of intelligence fail almost entirely and, at best, progress is slow and soon halted. The average case can scarcely succeed beyond the fifth grade. In the schools most of the pupils recognized by teachers as "very dull" and "very slow" will be found to have I.Q.'s between 70 and 85. Most of these children are retarded in their school progress. Children with I.Q.'s between 70 and 85 drop out early in considerable numbers, but many struggle along to finish the eighth grade, 1, 2, 3, 4 or more years retarded. It is found that most of those who persist are promoted more rapidly than their achievements warrant, mainly because they are bigger and older.

Average Intelligence.—Children of average intelligence—those whose I.Q.'s cluster closely about 100—set the pace in the grades. Examining the records of two hundred pupils, whose I.Q.'s range from 95 to 105, Terman found that aside from retardations clearly due to loss of schooling through illness or other causes, nearly all had made regular progress. The range 95 to 105 I.Q. includes about thirty-three per cent of the general population and probably about forty per cent of the population of the elementary schools.

Superior Intelligence.—Of fifty-four children between 120 and 140 I.Q.'s studied by Terman, 12.5 per cent were advanced in the grades two years: 54 per cent were advanced one year; 28 per cent were making average progress; and 5.5 per cent were actually retarded one year. Of a group of forty-seven children with a median I.Q. of 145, Terman found none retarded; 8.5 per cent at the grade corresponding to their age; 29.8 per cent advanced one year; 29.8 per cent advanced two years; 19.2 per cent three years; and 12.8 per cent four years. This is substantial evidence that the children of better than average I.Q. do exceed the average rate of learning such subjects as are taught in school, and that, on the whole, the higher the I.Q., the more rapid the progress.

Intelligence and Success in High School.—With regard to the limits of progress of high schools, much depends upon the standards of the school. I.Q.'s of 100 do complete the high schools, but in just what proportions is not known. Among first-year students in Palo Alto High School, the relation between achievement and I.Q. is shown in these figures collected by Proctor and Terman:

1 *School Marks*	2 *Average I Q.*	3 *Number of Pupils*
50–59	85	12
60–69	100	16
70–79	107	56
80–89	110	24
90–99	123	4

On the average, pupils with higher I.Q.'s earn the higher grades. Comparison of columns 2 and 3 gives an idea of the personnel of the first-year class in a first class

high school. Approximately two-thirds of the group are 100 or above, half are 105 or above, and a quarter are 117 or above in I.Q. At the end of the first year, of thirteen who dropped out of school, ten were below the median I.Q. (105) and of these, seven had failed in more than half of their subjects.

Intelligence and Success in College.—The minimum I.Q. required for successful work in college is not definitely known, since none of the Binet revisions contains tests sufficiently difficult to measure high adult intelligence.

In college, however, as in the lower schools, the correlation between intelligence and quality of work is positive and fairly high. For example, in Columbia College, the higher the rating on the Thorndike Intelligence test, the better the achievement in the classroom, on the average. In the accompanying table are given, in the first column, ranges of scores by tens on the Thorndike test (these are not I.Q.'s but raw test scores) and in the second column the percentages of students who received average classroom grades of "B" or better during a semester. To represent each range—*i.e.*, 60 to 70, etc.—fifty students were selected at random.

Range of Scores on Thorndike Test	*Per Cent of* 50 *Men in Each Range Who Averaged "B" or Better*
60– 70	4
70– 80	8
80– 90	14
90–100	30
100–120	50

Exceptionally High Intelligence.—What a child of very high I.Q. can do, under favorable educational opportunities, is illustrated by a case reported by L. S. Hol-

lingworth: E. . . . , in 1916, was a boy 8 years and 4 months of age, with an I.Q. of 187, and in Grade 8.

"In addition to this regular school work the child has covered the following special work in language and mathematics, either with a tutor or with his mother: Geometry, algebra, as far as equations; Latin, partial knowledge of the four declensions (he has been taught by the direct, informal method, and reads easy Latin); Greek—worked out the alphabet himself from an astronomical chart, between the ages of five and six years; French, equal to about two years in the ordinary school; German, ordinary conversation; Spanish, attended class with his mother,—reads and understands; Italian, reading knowledge, simple conversation; Portuguese, asked his mother to take this language at the Columbia summer school because he could not be registered himself; Hebrew, a beginner; Anglo-Saxon, a beginning. In astronomy he has worked out all the constellations from MacCready, and displays a very great interest in this subject. One evening this winter he noticed a new planet near the Twins. He said it was Saturn, but his mother thought it was Mars. E. . . . went home, worked the position out from the chart, and found it to be Saturn. He has a great interest in nature, wherever found, and is already able to use Apgar intelligently. His writing is not equal to his other accomplishments. He is very slow at it and for this reason dictates most of his 'home work' to a stenographer. History is his chief and absorbing interest among school subjects."

At the age of 9 E. . . . had completed the work of Grade 9; at 11 years and 10 months, graduated from high school; and at the age of 13 had completed three semesters of work in Columbia College. In capacity for scholastic achievement, this boy greatly surpasses the average.

In sum, there is impressive evidence that general intelligence as measured by the Stanford-Binet tests indicates with a faithfulness that makes it extremely useful practically the rate at which children learn *most school functions.* It sets a limit to the kind, difficulty, or complexity of mental functions that can be acquired, and it sets a limit to the rate and permanence with which acquisition, within these limits, may go on. Algebra and geometry as now taught, for example, are beyond the mental capacities of many, and among those who find these functions within the limits of their capacity, individual differences in the rate, comprehensiveness, and permanence of learning will be found, due to differences in endowment.

Intelligence and Particular School Subjects.

While the results of the Binet tests indicate very well the probable achievements in school work as a whole, they are not equally symptomatic of capacities in the particular subjects. The degree to which the tests indicate capacity in the several school functions is suggested by the coefficients of correlation between test scores and actual attainments. Taking as groups children in the same grades, Burt found the following average correlations:

Correlation Between *

Intelligence and composition	.63
Intelligence and reading	.58
Intelligence and arithmetic	.55
Intelligence and spelling	.52
Intelligence and writing	.21
Intelligence and handwork	.18
Intelligence and drawing	.15

* See the last section of the preceding chapter for the meaning of correlation.

These correlations show that the Binet tests do not measure native capacity in all scholastic lines equally well. The tests correspond quite closely to the children's ability in the linguistic and abstract subjects—composition, reading, spelling, arithmetic. Children with high I.Q.'s are generally superior to those of lower I.Q.'s in these subjects, but they are not markedly superior in writing, handwork, and drawing, that is, in mechanical and motor abilities.

Intelligence and Vocational Success.

Intelligence, as measured by the Binet tests, shows substantial correlations with general scholastic success, especially in such subjects which demand linguistic ability and the acquisition and manipulation of abstract ideas. Whether the same relations hold between intelligence and success in vocations under the more complex situations of life, is a matter worthy of investigation.

Unfortunately, the number of adults that have been measured by the Stanford test is limited. The test was not designed for adults. The Army Alpha, which was devised for this purpose, should yield results that are suggestive at least. The average scores on the Army Alpha test obtained by various occupational groups are shown in the following table.

Scores	*Occupations*
40 to 49	Farmer, laborer, general miner and teamster.
50 to 58	Hostler, horse-shoer, tailor, barber, general carpenter, painter, truck chauffeur, baker, cook, concrete or cement worker, mine drill runner, bricklayer, cobbler.
60 to 69	General machinist, lathe hand, general blacksmith, brakeman, locomotive fireman, auto chauffeur, telegraph and telephone lineman, butcher, bridge carpenter, railroad conductor, railroad shop mechanic, loco-

Occupations—(Continued)

Scores	
	motive engineer, laundryman, plumber, auto repairman, pipe fitter, auto engine mechanic, tool and gauge maker, stock checker, detective and policeman, toolroom expert, gunsmith, marine engineman, hand riveter, telephone operator.
70 to 79	—Truckmaster, farrier and veterinarian, receiving clerk, shipping clerk, stockkeeper.
80 to 89	—General electrician, telegrapher, band musician, concrete construction foreman, photographer.
90 to 99	—Railroad clerk, general clerk, filing clerk.
100 to 109	—Bookkeeper, army nurse, mechanical engineer.
110 to 119	—Mechanical draughtsman, accountant, civil engineer, Y. M. C. A. secretaries, medical officers.
Over 120	—Army chaplains, engineering officers.

When comparisons of radically different vocations are made, there is at once perceptible a tendency for vocations which require facility in dealing with words and symbols to stand higher than those which require aptitude for manipulating things and mechanisms. The clerical workers in general excel those engaged in mechanical occupations. The tests appear to have a verbal and linguistic bias; to favor those skilled in handling words and symbolic concepts as contrasted with those proficient in motor and mechanical abilities. This tendency appears both in the results of measurements of vocational groups as it did in the correlations of school subjects with the test results.

Further examination of the data, however, will disclose the fact that the intelligence test measures abilities which possess a wider significance. Making comparison within a similar type of occupation, the more skilled workers appear to stand higher on the intelligence scale than the less expert. The mechanical engineer and draughtsmen are above 110, the general electrician and construction foreman score about 85, the workers on more specific

tasks, such as automobile repairman, plumber, tool maker, bridge carpenter, auto chauffeur, etc., are below 70, while the unskilled laborers are at the bottom of the list. Among the several types of clerical workers, a similar correlation between intelligence and occupational levels exists. The chaplains surpass the Y.M.C.A. secretaries, the accountants surpass the bookkeepers, the medical officers are superior to the army nurses. Thus within similar occupational lines, general intelligence is associated with levels of proficiency.

It is significant that the members of the professional classes nearly always rank high in intelligence tests. In this connection, the average Army Alpha ratings of the students in various departments of a representative state university will afford interesting comparison with those of the occupational groups, just given.

MEDIAN ALPHA SCORES OF VARIOUS DEPARTMENTS IN OHIO STATE UNIVERSITY

(5,950 Students)

Department	*Score*
Liberal Arts	147
Medicine	142
Law	142
Engineering	141
Agriculture	133
Pharmacy	125
Dental College	115
Veterinary College	112

The medians of the students in most of these professional courses are well above all of the army occupational groups except the professional classes. A relatively high degree of general intelligence of this type is probably essential to success in the ministry, law, editorial work, medicine, banking, engineering, and other vocations for which college training is required.

A survey of the army occupational groups shows in general that those which stand high have probably had, on the whole, a greater amount of "schooling" than those standing low. The additional fact that college students do so well suggests the possibility that success in the Alpha test is largely determined by the amount of scholastic training. While this test probably is influenced more than the Binet Scales by education, it measures native capacity in the main, as the following sample data imply.

THE AVERAGE ALPHA SCORE, AVERAGE AMOUNT OF PREVIOUS SCHOOLING, AND AVERAGE SCHOLARSHIP RATINGS OF 42 STUDENTS OF THE U. S. VETERANS BUREAU IN STANFORD UNIVERSITY.

Number of Students	*Alpha Score*	*Average Previous Schooling*	*Scholarship Rating*
3	75–104	9 grades	0.0 (all total failures)
6	105–119	10.2 "	0 50
6	120–134	10.6 "	1 07
13	135–154	10.7 "	1.35
13	155–212	9.8 "	1.93

The scholarship rating was obtained by giving three credits for each "hour" of A work, 2 for B, 1 for C, and 0 for D or F. These credits were added, and the sum divided by the number of hours of work attempted. (From Proctor.)

The previous education of these groups differed very much less than the test scores. High test scores, rather than the advantages of previous schooling, seemed to foretell most accurately the achievements in the college courses. For example, one of the best records was made by a man who had the least previous education (5th grade) but a high Alpha score. Of four students who had previously done only the work of grade eight, two whose Alpha scores were very low failed in all of their

college subjects; a third whose Alpha score was in the second group earned a scholarship rating of 1.00; and the fourth, in the highest Alpha group, received a scholarship rating of 2.13, which was higher than that earned by any other student, without regard to previous education, whose Alpha score was below 155, *i.e.*, below the highest Alpha group.

INTELLIGENCE AND SOCIAL ADAPTABILITY AND LEADERSHIP.

Between intelligence scores and general school success, there is a substantial correlation; between intelligence and vocational success a marked, but as yet not thoroughly appraised, association. What is the correlation of abstract intelligence with social adaptability and leadership, with ability to get along with and manage people?

The use of the tests in the Army provided material that suggests a fair correlation between fitness for managing and leading men and intelligence ratings. The students of the Officers' Training Schools who succeeded in earning commissions were on the average of higher intelligence, according to the tests, than those who failed. Among non-commissioned recruits in the cantonments, the correlations of fitness for advancement as judged by officers and intelligence score was fairly high (.40 to .60). Finally, the average intelligence of seasoned troops corresponded fairly closely with military rank. In one group, which included approximately 30,000 men, the privates obtained an average Alpha score of approximately 73, corporals 95, sergeants 107, and commissioned officers 139. The overlapping of the intelligence scores of one rank upon others was great, however.

The relation between intelligence and social sagacity, adaptability and leadership has been indicated by studies of children. Among 150 first-grade pupils, intelligence

correlated with various traits judged by teachers as shown in the accompanying table:

Correlation of Stanford Binet I.Q. and Traits as Indicated
(From Terman after Dickson)

Trait	*Correlation with I.Q.*
Social adaptability	.47
Leadership	.44
Self-expression (speech)	.37
Popularity among fellows	.34

These results show much the same general relations as those obtained on adults in the army. All lead to the conclusion that the intelligence tests correlate in some degree, but by no means perfectly, with the capacities required in understanding, getting on with, and managing other human beings.

Intelligence and Moral Adjustments.

Fine gradations of moral adjustments are difficult to obtain. We may seek for some evidence in the studies of the relation of intelligence to delinquency and crime. Of this association, it is impossible to make a precise statement, so diverse are the findings of different investigators. For example, one authority asserts that "probably 80 per cent of the children of the Juvenile Courts in Manhattan and Bronx are feeble-minded," another, that of the cases in the Newark Detention Home, N. J., 66 per cent are "distinctly feeble-minded"; another that "one-third of our delinquent children are feeble-minded"; another that about 8 per cent are. For these discrepancies there are several explanations of which two are important:

(1) The diagnosis of "feeble-mindedness" has not in all of the studies been based on tests of intelligence alone;

and even when it has been, the line of demarcation between "normal" and "feeble-minded" is drawn at different levels;

(2) The studies are usually based on different institutions which are devoted to quite diverse types of delinquency or crime.

Of the many individual studies, one made by Burt will be considered because it is probably fairly typical and because of the care with which both intelligence and other abilities were measured. The group comprises 107 juvenile delinquents, ages six to fifteen, whose misdemeanors include theft, begging, truancy, assault, sexual offences, damage to property, and general incorrigibility. The average chronological age of the entire group was 13.2 years, the average mental age 11.3, thus giving an average retardation of two years in mental age or an average I.Q. of 85.6. Analyzing the distribution further, it is found that 7 per cent might be classified as "feeble-minded"; 20 per cent as very dull; 50 per cent as less dull but below average; 25 per cent as about average; and only 2 per cent as slightly above average. Supernormal intelligence among children is not incompatible with delinquency; but delinquents of high intelligence are rare. While the proportion of feeble-mindedness in the delinquent group is not great, it is at least five times as great as the proportion of feeble-mindedness in the total population. The more significant fact, however, is that the delinquent group, as a whole, is a dull group; only 2 per cent are above the average.

Typically, then, the delinquent child is a dull child but not all dull children are delinquent. Social and moral deficiency is explained by dullness plus something else, or, probably, plus several other things. To some extent, the other traits are probably emotional and temperamental

deficiencies or nervous instability. The compelling drives of the dominant urges, the incapacity for sustained effort, fickleness of interest, or the disrupting effects of unstable but impulsive emotions when combined with dullness of mind provide an organism readily susceptible to misdemeanor and crime. Many delinquent children are, however, not obviously instable or excessively impulsive or deficient in restraint. Environmental factors—unfavorable home, school or street influences—are sometimes the inciting causes.

Conclusions.

The results of tests, such as the Binet or the Army Alpha, together with studies of the inheritance of mental traits lead to the assumption of general intelligence. By intelligence is meant a group or composite of native capacities for learning along the lines that require mental operations with verbal, symbolic and abstract materials. In these fields, the more intelligent person learns more rapidly, displays greater mental keenness, accuracy and control in meeting new problem-situations, and is capable of ascending to higher levels of achievement than the less intelligent person.

The intelligence tests do not measure all types of capacities to learn, but those which are tested are of great importance. Upon such capacities mainly depends achievement in school and colleges and success in many vocations. Social adaptability, proficiency in managing people, and effectiveness of moral adjustments are also associated to an appreciable degree with this type of intelligence. The correlation of intelligence with ability to acquire various mechanical and motor skills—writing, drawing, painting, athletics, and various mechanical trades—is positive but low.

QUESTIONS AND EXERCISES

1. Following are definitions of intelligence offered by other writers. Which of these are most serviceable and valid?
   a "The general capacity of an individual consciously to adjust his thinking to new requirements."—Stern.
   b "An individual is intelligent in proportion as he is able to carry on abstract thinking."—L. M. Terman.
   c "To judge well, understand well, reason well, these are the essentials of intelligence."—Alfred Binet.
   d "Intelligence seems to be a biological mechanism by which the effects of a complexity of stimuli are brought together and given a somewhat unified effect in behavior."
   —Joseph Peterson.
2. Basing your opinion on the facts presented in the chapter, does it appear that the definitions above are too broad or too narrow to *define* what the present tests actually measure?
3. Aside from tests, what features or kinds of behavior disclose in some measure the degree of intelligence that a person may have? For example, are table manners or English usages indicative of intelligence?
4. In which of the following types of work is a high degree of intelligence probably useful or necessary: driving an automobile, fishing with nets, splitting wood, taking shorthand dictation, barbering, preaching, teaching, running a riveting machine, writing poetry, selling toy balloons, selling bonds. In which of these activities are traits other than intelligence important? What traits?
5. Is it possible that for some tasks too much intelligence as well as too little intelligence would be a handicap? Give examples and tell why a college graduate of superior mind would do the job badly?
6. What services could an expert in intelligence testing render to the work in: (a) a juvenile court; (b) a hospital for neurotic children; (c) a public school; (d) a criminal court; (e) a home for orphans; (f) an automobile factory; (g) a large department store; (h) an immigration bureau; (i) the army or navy.
7. Explain in some plausible way the fact that intelligent people, on the whole, are less conceited than are dull.

8. To what extent are the factors which are involved in reasoning also involved in taking intelligence tests? Do you think the reasoning tests given in Chapter 14 would make good tests of general intelligence?
9. A boy of 10 with an I.Q. of 140 would have what mental age? A boy of 14 with an I.Q. of 100? In what respects would these two boys resemble each other or an adult with an M.A. of 14? In what respects would the three be very unlike?
10. If you were selecting children to form a homogeneous grade, what measure would you use, the M.A. or the I.Q.? Why?
11. What arguments or evidence can you offer to support the contention that intelligence tests measure the results of school training mainly? How might the facts be determined experimentally?
12. Carefully distinguish between intellectual capacity and achievement.
13. Do you suppose the methods of teaching which are best for I.Q.'s of 130 and over are best for those of 100? For those of 70?
14. Comment on this statement, "It may be of greater value to society to discover a single gifted child and aid in his proper development than to train a thousand dullards to the limit of their educability."
15. How would you explain the fact that children of superior intelligence when graded with those of the same age occasionally become mischievous, lazy or bored with school work? Does the occasional report of an eminent man getting along badly in school, if true, necessarily prove that such men were stupid when young or that they were unable to do school work?
16. If children were to be grouped according to Mental Age, what difficulties of administration would be encountered? What, if any, difficulties in social adjustments?
17. Have you observed any cases of irregular educational development, of spurts or arrests, or of changes in apparent brightness? Might these irregularities be only apparent? Might they appear in scholastic achievement without being occasioned by similar variations in mental development?
18. Is it your experience that the more intelligent people are more or less socially adaptable? How would you explain the exceptional cases?

19. How might intelligence tests be used in vocational guidance? When should they be so used?
20. When a child's I Q. becomes higher or lower on a retest, does it necessarily mean that his intelligence has changed correspondingly?

GENERAL REFERENCES

The most comprehensive single survey of the whole field of intelligence testing is R. Pintner's *Intelligence Testing: Methods and Results,* New York: Henry Holt, 1923.

For a general account of the Stanford Revision of the Binet Scale see L. M. Terman, *The Measurement of Intelligence,* Boston: Houghton Mifflin, 1916. Data on the use of the tests in schools are given in *Intelligence of School Children,* by the same author and publisher, 1919.

The use of the Binet tests in England is described in Cyril Burt, *Mental and Scholastic Tests,* London: P. S. King, 1921.

The use and results of mental tests in the American Army during the War are described briefly in C. S. Yoakum and R. M. Yerkes, *Army Mental Tests,* New York: Henry Holt, 1920, and more fully in Vol. 15 of the *Memoirs of the Natural Academy of Science,* 1921, edited by R. M. Yerkes.

Other books on special phases of the use of intelligence tests follow: L. S. Hollingworth, *The Psychology of Subnormal Children,* New York: Macmillan, 1920; Herbert Woodrow, *Brightness and Dullness in Children,* Philadelphia: Lippincott, 1919; Wm. Proctor, *Psychological Tests and Guidance of High School Pupils,* Bloomington, Ill.: Public School Publ. Co., 1921; W. F. Book, *The Intelligence of High School Seniors,* New York: Macmillan, 1922; B. D. Wood, *Measurement in Higher Education,* Yonkers: N. Y. World Book Co., 1923; M. R. Furnald, M. H. Hayes and A. Dawley, *A Study of Women Delinquents in N. Y. State,* New York: Century, 1920; J. B. Miner, *Deficiency and Delinquency,* Baltimore: Warwick and York, 1918. H. C. Link, *Employment Psychology,* New York: Macmillan, 1919; H. H. Goddard, *Feeblemindedness: Its Causes and Consequences,* New York: Macmillan, 1914; H. H. Goddard, *Human Efficiency and Levels of Intelligence,* Princeton: University Press, 1922; H. C. Hines, *Measuring Intelligence,* Boston: Houghton Mifflin Co., 1923; C. C. Brigham, *A Study of American Intelligence,* Princeton Univ. Press, 1923.

CHAPTER XIX

THE MEASUREMENT, ORGANIZATION AND SIGNIFICANCE OF VARIOUS HUMAN TRAITS

In the preceding chapter, we considered the means of measuring and the significance of individual differences in a complex native trait, general intelligence. Intelligence, it was found, exerts an influence on achievement in scholastic subjects, vocational success, social and moral adaptation. The correlations were never perfect and sometimes only moderate or low. While imperfections in the tests and inequalities in opportunity to learn are in some measure responsible for the appearance of imperfect correspondence between intelligence and attainment, it is probable that, to account fully for achievement in particular tasks or adaptation socially and morally, traits other than general mental ability must be taken into account. The human personality is broader than intelligence; perfect adjustment to the demands of life depends on aptitudes of other types, and to many of these the science of human measurement has recently been devoting active attention. In this chapter, we shall consider briefly some of the facts concerning the identification, measurement and organization of various human traits.

The Measurement of Attained Abilities.

The Unreliability of Subjective Estimates of Ability. —In appraising any individual, a pupil reported as exceptionally poor or good in school, a youth seeking coun-

sel as to his vocational fitness, an adult contemplating a change in vocation, or troubled with unusual fears or guilty of misdemeanor, the examiner is interested, among other things, in the individual's attainments. Precisely what abilities has the person acquired; what can he do; what does he know? The need of objective tests is here quite as imperative as in appraising other human traits. In earlier chapters the unreliability of subjective esti-

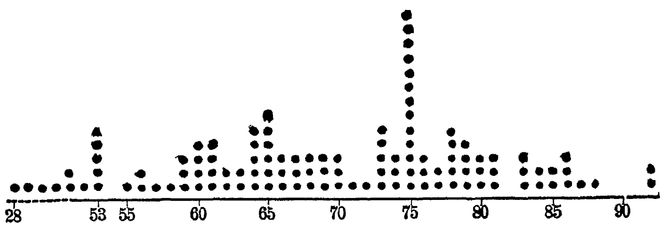


FIG. 68.—DISTRIBUTION OF MARKS ASSIGNED TO A FINAL EXAMINATION PAPER IN GEOMETRY BY 114 TEACHERS OF MATHEMATICS. Each dot represents the mark given the paper by one teacher. Marks represent percentages of excellence. (From Starch, *Educational Psychology,* after Starch and Elliott.)

mates of aptitude for selling clothes, or of trustworthiness and sociability were disclosed and from experimental studies it appears that subjective evaluations of ability, scholastic, social or vocational, are similarly inexact. For example, in one experiment a final examination in geometry was graded by 114 teachers of that subject on a percentage basis, with results as shown graphically in Figure 68. The scores range from 28 to 92. Similar results have been obtained in other subjects. That these variations are not due mainly to differences in the standards of different schools is indicated by studies of teachers in the same schools and colleges. The variations have been nearly as great. Even when the same teacher after an interval regraded a set of papers, the marks differed appreciably from those on the first scoring. Such

inadequacies in appraising ability by judging products are duplicated by errors in judgments of performances directly observed. The need of standardization of conditions and objective evaluation is clearly great.

Standardized Tests and Scales.—The requirements for objective measurement embrace two devices, a *standardized test* and a *scale*. Any series of questions, exercises, problems, or performances constitutes a test. When the procedure for conducting the test, the instructions, time, and methods of scoring results are prescribed, we have a standardized test. For many standardized tests now in use, scales have been constructed by means of which the results of the test may be evaluated. A scale is a series of test scores ranging from lowest to highest by steps of known, usually equal, magnitude or a representation of a series of products which range from very poor to excellent by steps of known or equal magnitude. The scale may be in terms of difficulty, range, speed or quality, or some combination of these. A few illustrations will make this clear.

Difficulty Scales.—A difficulty scale is developed by trying out on a number of persons a series of problems or tasks and ascertaining the number who succeed in each. The fewer the persons who succeed, the harder the problem must be. With the difficulty of the tasks thus determined, they are arranged in order from the easiest to hardest. The examinee then begins at the easy end of the scale and progresses as far as he can in the time allowed, which is usually liberal. This will be recognized as the principle of the Binet Intelligence Scale. Among scales of this type are several for scholastic attainments. There are scales for reading comprehension which seek to determine how difficult a passage the subject can understand; others for attainment in arithmetic, algebra, and

geometry, which seek to disclose how difficult a problem one can solve, and others of the same character in word knowledge, history, grammar, spelling, etc. Some of the Trade Tests, constructed by psychologists for determining vocational competence of soldiers before assignment to duty in the American army during the late war, were difficulty tests. Similar tests and scales are now used in many industries.

Range Scales.—The range of information and ability disclosed by a test may be scaled in the same manner as the difficulty, the number of correct answers given or tasks done out of the total number, more or less equal in difficulty, forms the basis of the scale. In the range test, the time allowance is liberal or unlimited. The range of information or ability is often of considerable concern to an employer in appraising fitness for some position. This form of test was prominent in the Army Trade Test series and is used widely in industries.

Speed Scales.—The speed scale is designed to measure the amount of work of a uniform quality and difficulty that a subject can do in a prescribed time. The number of words per minute written by hand, typed, set up on a line-o-type, transmitted or received in telegraphy, recorded or transcribed in shorthand; the number of bricks laid, square feet painted, papered, spaded, etc., are all samples of speed tests. The scale is a standard series with which to compare results of the test.

Quality Scales.—The quality scale (a sample and the method of derivation of which was described on pages 397-399) consists of a series of sample products of writing, drawing, stitching, composition, carpentry or what not, ranging from very low to very high merit by equal or known steps. A sample product, obtained during a standardized test, is compared with the samples on the

scale and given the score which it matches in merit. The value of the scale is that it provides a standard of comparison and a device by means of which the examiner's estimates may be improved and expressed in terms of a uniform currency. This type of scale was also utilized in the U.S. Army Trade Tests.

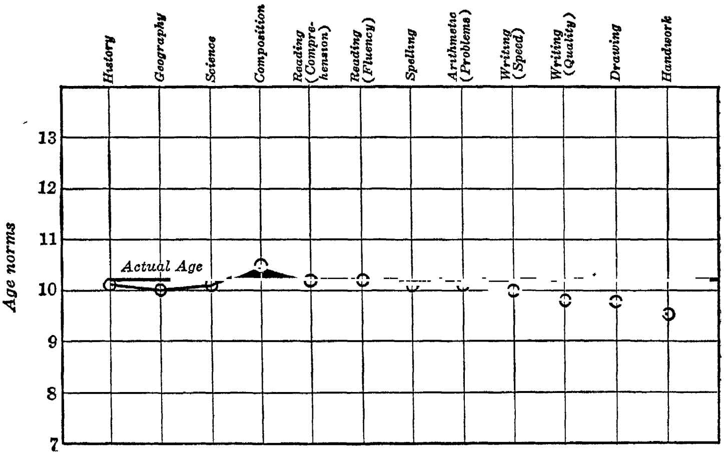


FIG. 69.—A PROFICIENCY PROFILE OR "PSYCHOGRAPH" FOR SCHOLASTIC ABILITIES. The straight heavy line shows the pupil's actual age and indicates also the *average* of the abilities of children in general of the same age. This pupil has an exceptionally even profile, and is about average on the whole. In the mechanical subjects, writing, drawing and handwork, he is from a third of a year to nearly a year below the norms. (Modified after Cyril Burt, *The Distribution and Relations of Educational Abilities*, London: P. S. King, 1917.)

THE CONCEPT OF SPECIAL APTITUDE AND INAPTITUDE.

Variations Shown in Proficiency Profiles.—With the application of standardized tests to individuals of the same race, sex, age, intelligence and general training, it was found that, even with these factors constant, abilities were not uniform but varied in magnitude. Individuals whose scholastic abilities are, on the whole, about equal

show particular high and low proficiencies in particular subjects. The variations appear most clearly in what may be called proficiency profiles, or "psychographs," of which Figures 69, 70, 71 and 72, are samples. The variations in the average case are considerable and in extreme instances an individual shows a wide departure from his

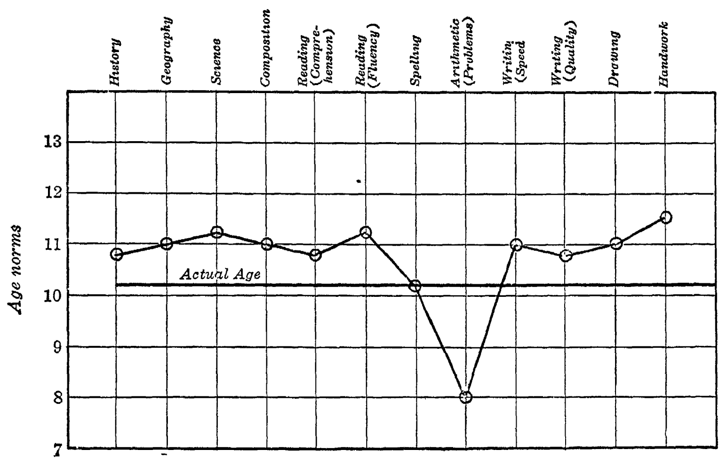


FIG. 70.—A PROFILE SHOWING ABOUT AVERAGE ABILITY OR A LITTLE BETTER, BUT A SPECIAL DEFICIENCY IN ARITHMETIC. The best subject in this case, unlike Fig. 69, is handwork. (From Burt, *op. cit.*)

own average proficiency. Specialization in achievement is apparent. How is it to be explained?

Causes of Special Aptitude and Inaptitude.—Without doubt the variations are partly due to environmental factors, to special encouragement or neglect, to good and bad instruction, to effective and ineffective technique acquired often by accident, and to other differential results of experience. There is considerable evidence, however, that these are not the sole causes of such variations in an individual's proficiency profile, but that the variations are determined in part by inherited capacity—

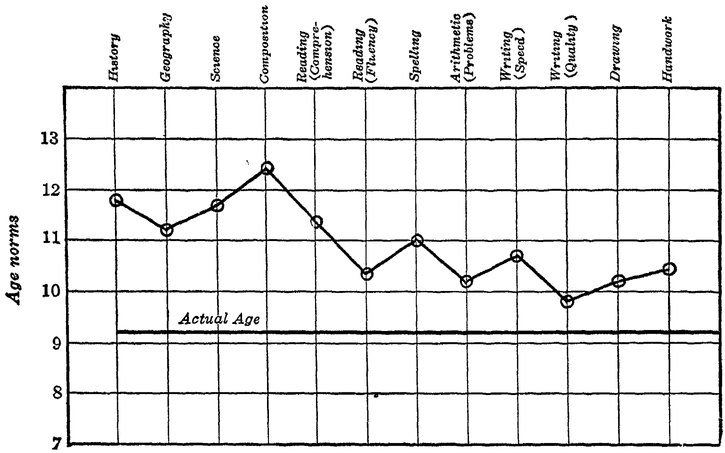


FIG. 71.—HIGH AVERAGE ABILITY WITH SPECIAL PROFICIENCY IN COMPOSITION. History and science also are excellent. This degree of irregularity in a profile is not unusual. (From Burt, *op. cit.*)

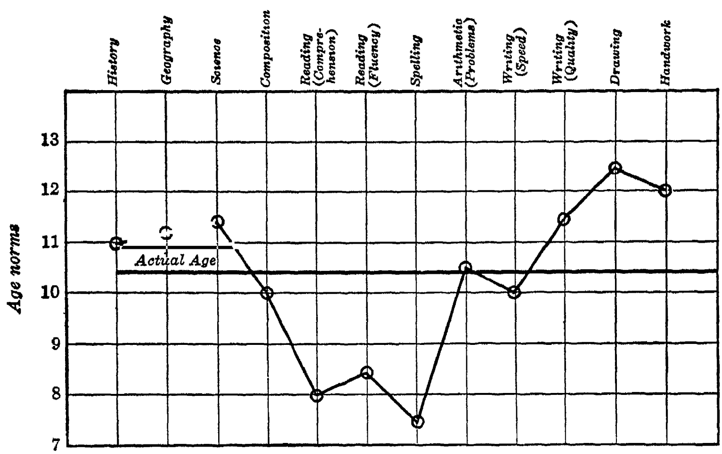


FIG. 72.—A VERY IRREGULAR PROFILE SHOWING SPECIAL PROFICIENCY IN DRAWING AND HANDWORK WITH EXTREME DISABILITY IN THE LINGUISTIC ARTS, COMPOSITION, READING AND SPELLING. (From Burt, *op. cit.*)

special aptitude or inaptitude for learning—along specific lines.

The evidence in favor of this belief in specialized capacity is much the same as that which suggests the inheritance of general mental ability. Special aptitudes for composition, typing, mathematics, debating, handwork and the like appear when environment and training have been uniformly good or bad; special inaptitude is often found which persists despite unusual effort, instruction and encouragement. Finally, special abilities and inabilities often run in families as the studies of the inheritance of individuals eminent in music, painting, mathematics and science or possessing special deficiencies in these and other functions have shown.

Tests for Special Aptitudes or Capacities.—Since each individual, then, possesses to some extent special aptitudes and inaptitudes for developing ability, specialists in the field of measurement have endeavored to construct objective tests for special capacities of many sorts. These tests for special aptitudes may be classified by location on a scale which extends from tests at the one extreme which may be called *analytic tests*, to the other extreme, at which are the *symptomatic performance tests.*

Analytic Tests of Aptitude.—An excellent example of the analytic tests are the Seashore Tests for Musical Aptitude. Like other tests of this type, the Seashore series is an aggregate of particular tests for the many particular abilities which have been found, in experimental and analytic studies, to be involved in musical ability. In brief outline the tests are:

- I. Tests of Musical Sensitivity
  - A. Simple forms of impression
    1. Sense of pitch
    2. Sense of intensity

3. Sense of time
4. Sense of extensity

B. Complex forms of appreciation
1. Sense of rhythm
2. Sense of timbre
3. Sense of consonance
4. Sense of volume

II. Tests of native capacity for acquiring skill in motor production of tones, vocal, instrumental or both.
1. Control of pitch
2. Control of intensity
3. Control of time
4. Control of rhythm
5. Control of timbre
6. Control of volume

III. Tests of musical memory and imagination.
1. Auditory imagery
2. Motor imagery
3. Creative imagination
4. Memory span
5. Learning ability

IV. Tests of musical intellect.
1. Musical free association
2. Musical power of reflection

V. Tests of musical feeling
1. Musical taste
2. Emotional reaction to music
3. Emotional self-expression in music.

Since all of these abilities are involved in music, it follows that aptitude for music is not to be conceived as a unit trait or a single and simple capacity. On the contrary it is an aggregate of many. Excellence in one, coupled with deficiencies in others, would not suffice for achievement. Some single deficiencies such as the capacity to discriminate pitch within certain limits—a capacity that is usually native and unimprovable—would, on the other hand, make progress impossible however optimum the capacities in other respects. The apt individual is the one who approaches an optimum degree of

native endowment in all. A final appràisement of musical aptitude would, consequently, be based on a consideration of many constituent capacities, each weighted in accordance with its importance.

It is probable that all aptitudes such as those for driving automobiles, writing verse, pole vaulting, selling clothes or doing other complex tasks, are also based on composites of many particular capacities, each necessarily present in a certain degree. Above the minimum degree essential, further increments may add to the possibilities of achievement until an optimum amount is reached. Possession of that capacity in greater amounts may be of no value; indeed it might be a disadvantage. Thus it has been found that too much as well as too little intelligence, as compared to a certain optimum range, makes efficiency in certain industrial jobs less likely. A philosopher might fail as a barber as completely as the imbecile; one may be too swift as well as too slow to handle certain machines with efficiency, too talkative as well as too taciturn to be a good salesman.

Symptomatic Performance Tests.—At the other extreme from tests which are designed to measure in relative isolation the many capacities which analysis of the function discloses, are the tests for convenience called symptomatic performance tests. Such tests are usually few rather than many, and may be of any type whatsoever, the only requirement being that achievement in them is symptomatic of aptitude for the ability in question. Often the test includes in one performance a number of abilities that are correlated with the aptitude. An example of such a test is the Stenquist Test for Mechanical Aptitude which was used widely on soldiers during the war and has been, before and since, used in schools and industries.

The Stenquist Test includes two parts. The Assembly Test consists of a series of mechanical objects taken apart —a bicycle bell, a paper-clip, a lock, a mousetrap, etc.— which the examinee is to assemble as correctly and rapidly as possible. Both speed and accuracy are scored. The other part consists of a series of pictures of mechanical devices, blocks and tackles, gear assemblies, etc., the functions and relations of which are to be indicated by letters and other marks.

Such tests are not based on exhaustive analyses of the capacities involved in mechanical work, nor is it likely that all mechanical capacities are tested. The justification of the test for purposes of indicating mechanical aptitude is based solely on the degree to which the results are symptoms of aptitude or inaptitude. They are symptomatic of capacity in much the same way that change in blood pressure, pulse and temperature are symptomatic of prospects of good or poor health or of the presence or absence of a particular physical disease.

Tests for aptitudes in stenography, salesmanship, accounting, drawing, writing, reading, engineering, and various particular industrial tasks lie at various points between the extremes. Most of them embrace features of both, that is, particular tests of operations identified as entering into the work and others that are not clearly tests of a specific ability, but of functions that have proved to be symptomatic of ability. The tests for aptitude in aviation during the war included both.

The range of special aptitudes is broader than industrial, vocational, scholastic and aesthetic activities; it includes the social, moral, religious and other phases of life. Undoubtedly some are born with better equipment than others for understanding, liking, getting along with or managing other people, for perceiving, resisting and

combating moral temptations, for appreciating, accepting and living by religious standards. In these fields objective means of appraising native strengths and weaknesses in particular forms are not as yet numerous or refined. Some approaches to the measurement of aptitudes and abilities that are perhaps involved in adjustments in these phases of life will be mentioned presently.

Main Conclusions from Studies with Tests of Special Aptitudes.—Out of the numerous studies of special talents and attainments has developed the concept of specialized aptitude. Like general intelligence, a special aptitude is conceived to be native, to indicate the possibility or capacity for development along a particular line. As in general intelligence, individuals differ in special capacities approximately as portrayed by the probability surface. A special aptitude is not, however, a single, isolated functional unit but merely an aggregate of more minute capacities. In each and every vocational, social or scholastic task, a number of minute capacities are involved. For one task, such as reading, a certain aggregate is utilized; for another, such as playing the piano, another group, and so on. Between any two combinations there may be an overlapping, great or small. In the development of measuring instruments, attention has been given both to the narrow capacities and abilities and to the broader aggregates, or special aptitudes and abilities.

The Measurement of Emotional, Temperamental and Other Traits of the Personality.

Achievement in a particular task, then, depends largely upon native capacity for that particular function. But given equal capacities, equal general mental ability, equal opportunity, instruction and encouragement, differences

in achievement still appear. How are these remaining discrepancies to be explained?

In part, they may be explained by differences in temperament, which is in considerable measure the resultant of activities of the endocrine glands; by differences in general emotionality and general nervous stability; by differences in the strengths of the fundamental urges; by differences in habituated forms of mental adjustments such as day-dreaming or active compensation. The differences in achievement in whatever line depend in some measure on traits of personality that are not included as specific items in the aggregate of special capacities which together are spoken of as aptitude for acquisition of music, selling ability, oratorical ability, and so on. The importance of temperamental and other dynamic traits has been already emphasized; only a few words concerning efforts to measure them need be added.

Measurement of Strengths of the Dominant Urges.—Each of the dominant urges discussed in Chapter VIII offers a clue to the study of traits of the personality which may influence achievement in any line as well as adjustment generally. Some individuals are more pugnacious than others; some more obstinate, masterful, or self-assertive; some are more acquisitive, curious, kindly, gregarious, or more prone to laughter, to crying, or to fear; some have stronger sex and parental propensities; some are more zealous to secure social approval; some are more responsive to rivalry. All told, these fundamental dispositions constitute an important stock of dynamic factors. That the task of measuring these traits of personality is not as yet far advanced is substantial evidence not of indifference but of the complexity and difficulty of the tasks involved.

For several traits, such as aggressiveness or self-asser-

tion, perseverance, optimism, stubbornness, and flexibility in adjustment and ambition, tests have been devised and are now being subjected to trial. Among the most ingenious and most promising is the Will-Temperament Test devised by Downey, which includes twelve specific tests, based mainly on handwriting, for such traits as the following:

1. Speed of movement (whether a person naturally moves quickly or slowly).
2. Freedom from load (the tendency to warm up rapidly and work at high speed without external pressure).
3. Flexibility (ease and effectiveness in readjustment or adaptability).
4. Speed of decision.
5. Motor impulsion (impetuosity and energy of reaction).
6. Reaction to contradiction (the degree of confidence with which one maintains his opinion against contradiction).
7. Resistance to opposition (the tendency to overcome obstruction).
8. Finality of judgment (whether one wavers or perseveres in his opinions).
9. Motor inhibition (a test of "motor control, imperturbability, and patience").
10. Interest in detail.
11. Coördination of impulses ("capacity to handle a complex situation successfully without forgetting any of the factors involved").
12. Volitional perseveration ("willingness to keep plugging away").

Downey's method is to use the scores for each test independently, displaying them for purposes of compari-

son in a graph which portrays the will-temperament "profile." Figure 73 gives a sample profile. A balanced profile running from scores 4 to 6, according to Downey, suggests a less speedy, forceful, and accurate individual

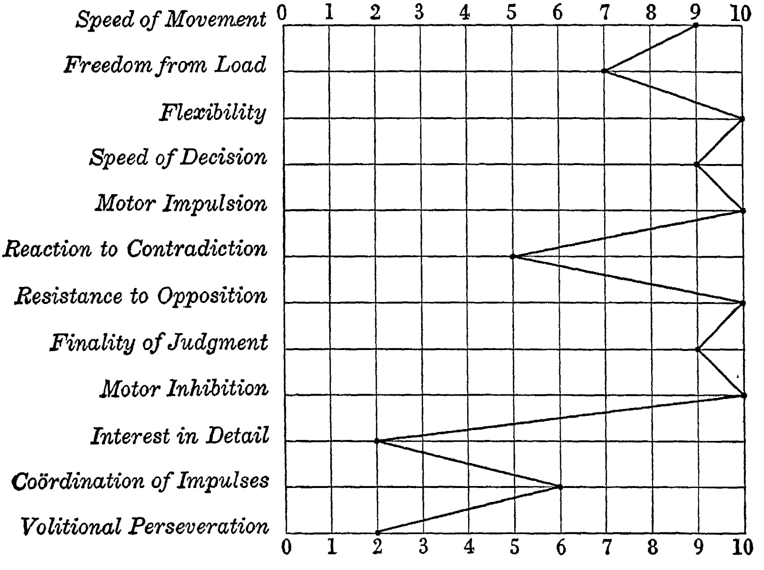


FIG. 73.—THE WILL-TEMPERAMENT PROFILE OF AN ADULT WHO "HAS HELD A NUMBER OF IMPORTANT EXECUTIVE POSITIONS. He is, in addition, an effective public speaker and possesses great dramatic talent. His profile suggests, in general, the type of the successful administrator, especially with reference to the high scores for speed of decision, finality of judgment, freedom from load, resistance to opposition and motor impulsion in conjunction with high motor inhibition. The high score for flexibility and the medium one on reaction to contradiction (tactful response) indicate social pliability and suggestibility which increase X's social assets, but are of dubious value in his business life. The low score on interest in detail is not a serious defect, since X is in a position to turn over to subordinates the execution of many of his projects. It goes, however, with a tendency to generalize on insufficient grounds. The low score on volitional perseveration is probably a real weakness." (Graph and Quotation from Downey. *Manual of Directions*, copyright 1921, published by the World Book Company.)

than a profile ranging from 8 to 10. High scores on such traits as speed of movement and decision, freedom from load, flexibility, and motor impulsion are said to characterize an individual as mobile or rapid-fire in organization, whereas high scores in motor inhibition, interest in detail, coördination of impulses and volitional perseveration are characteristic of the controlled, deliberate, painstaking person. Many combinations are possible among the twelve tests but they are not so numerous as to exaggerate the multiplicity of temperaments found in human nature.

How faithfully the Will-Temperament Tests represent the traits they purport to measure has not as yet been determined with finality, but the tests have opened a fruitful field for research.

Measurement of General Emotionality, Nervous and Mental Stability.—General emotionality and instability of nervous and mental types may be subdivided into several varieties by expert diagnosis although even among specialists classification is by no means uniform. Diagnosis is based upon symptoms, present and past, reported by the subject or upon observation of behavior or both. Each specialist places varying emphasis on certain symptoms; some of which given great weight by one are considered as of little significance or disregarded by others. During the war, an inventory of the symptoms utilized by many leading specialists was made and organized into a questionnaire by Woodworth. Used during the war in the study of psychoneurotic and emotional soldiers and since upon laymen, it has provided material for the appraisement of the significance of symptoms which were previously of unknown value. In the original form, the Woodworth Psychoneurotic Questionnaire included 116 items. The following are samples:

1.	Do you usually feel well and strong?	Yes	No
10.	Do ideas run through your head so you cannot sleep?	Yes	No
20.	Do you have queer, unpleasant feelings in any part of the body?	Yes	No
30.	Did you have a happy childhood?	Yes	No
40.	Have your employers generally treated you right?	Yes	No
50.	Are you ever bothered by the feeling that things are not real?	Yes	No
71.	Can you do good work while people are looking on?	Yes	No
98.	Do your feelings keep changing from happy to sad and from sad to happy without reason?	Yes	No
108.	Have you ever been afraid of going insane?	Yes	No
114.	Can you stand the sight of blood?	Yes	No

The average number of symptoms or positive responses out of the possible 116 was, for white recruits in general, 10; for college students, 10; for the psychoneurotic soldiers encountered during recruiting, from 30 to 40. For a preliminary appraisement of general instability the test has proved useful and further work may make more differential diagnosis possible.

Association Tests of Temperamental and Character Traits.—Among the devices for appraising various emotional, temperamental and other character traits, association tests were early suggested. They fall into two types, the *free* and *controlled* association tests. In using the free association method, the examiner presents the subject with a stimulus word selected to initiate a flow of associated ideas in some phase of experience. The subject is expected to permit his thoughts to rove freely and to report what occurs to him. Ideas thus aroused by such words as *money, business, marriage, enemies, fears, family,* may furnish the experienced examiner with clues as to the subject's difficulties or "complexes" and his type of thinking, whether pessimistic or optimistic, extra-

vertive (*i.e.*, impersonal and objective) or introvertive, or whether systematic or scattering. Recently, tests in which the associated responses are more thoroughly controlled and comparable with standards have found greater favor. Two lists of 100 words each have been given, a word at a time, to a large number of adults (Kent and Rosanoff) and to children (Woodrow and Lowell) respectively, and the results recorded. For each word is thus available a table of frequencies of responses. Peculiar and symptomatic associations are more readily distinguished from the normal. Numerous other varieties of controlled association tests are at present undergoing study. Thus far, the association method has been of demonstrable value only when utilized by experts for certain limited purposes, mainly to make a preliminary survey of the mental or temperamental predispositions of patients, abnormal or suspected of being abnormal.

Summary.—These are samples of various devices and evidences of active efforts being made to disentangle and objectively measure the innumerable aspects of the dynamic personality. Although certain forms of attack, such as by use of association tests in some form, are by no means recent, the validity of most tests of these complex traits of personality has not been determined with precision. At least, progress is being made. As the validity of the objective tests are demonstrated, the rôle of the emotional, temperamental and volitional aspects of the personality in modifying achievement and influencing adjustments to life generally will be more perfectly determined.

Personality "Types."

It is usual in the study of traits of personality to become interested in "types," and to attempt to classify all

individuals into one or more such types. The traditional types, the sanguine, or animated and cheerful; the melancholic or depressed; the choleric or quick, high strung, easily provoked; and the phlegmatic or slow and calm, are often preserved under new names and frequently other varieties added, but a disposition has remained to reduce all to a relatively small number of types. By this procedure, two errors are likely to be encountered. The first is the erroneous notion that individuals fall into several rather discrete groups, each group characterized by one or another trait, that individuals tend to be at one or another extreme. This is quite untrue; in sanguineness or any other such characteristic, individuals vary continuously from one extreme to the other, with the largest number clustered midway. In all these traits, in other words, individuals are distributed more nearly in accordance with the normal curve than in accordance with a curve thinly populated in the middle as compared to the extremes. Most individuals are neither conspicuously irascible or calm, buoyant or depressed, self-assertive or submissive, introvertive or extravertive, but nearer the average than these extremes. The extremes, then, are not "types" in the sense of being the most typical of the whole group. On the contrary they are numerically least typical. The most representative individual is the average.

The second erroneous suggestion arising from classification into a small number of types is that the personality consists of but relatively few characteristics. This is quite incorrect; the list of human traits is long, and the permutations and combinations of varying amounts found in particular individuals are almost innumerable. What traits constitute a person—so far as his general adjustments and activities in the everyday give-and-take rela-

tions are concerned—has been disclosed in some measure; but heretofore many traits have been considered in isolation from others. Other things being equal, a high degree of intelligence is more productive when found in a healthy body. A powerful voice alone will not make a successful statesman, nor will a fine physique. The race is not always won by the merely swift. For many forms of adjustment and achievement a certain *combination* of traits is required.

The varieties of combinations of traits which are found in individuals are too numerous to make feasible even a rough grouping. We shall consider merely two outstanding and easily identifiable groupings in order to disclose certain pertinent facts.

Sex Differences.

If an attempt were made to divide the human race into types of personalities, no grouping could be more obvious and, if popular opinion were reliable, no groups more conspicuously different than male and female. In fiction and in pseudo-scientific literature, sex differences are described in number and degree so great as to make man and woman appear to be members of nearly distinct species. This is doubtless due in part to a tendency to compare extreme cases of the two groups. It may be said at the outset that while sex differences do exist, they are less great on the whole than has generally been supposed. Before considering male and female personalities as a whole, it will be necessary to consider the differences in specific traits. In gross physical traits—height, contour, weight, strength, and appearance—sex differences are most spectacular, a fact which doubtless has had an influence on the judgments of mental and temperamental

traits. But even in physical traits, the overlapping of boys and girls of the same age, or of men and women is considerable.

In general intelligence sex differences are *less* conspicuous than physical differences at all stages of growth as is shown in the following table based on the Binet Mental Ages of 1000 children measured by Terman and 3500 measured by Burt.

DIFFERENCE IN MENTAL AGE (YEARS) IN FAVOR OF GIRLS

Average Chronological Age	*Terman*	*Burt*
5.5	0.22	0.4
6.5	0.39	0.6
7.5	0.15	0.5
8.5	0.17	0.3
9.5	0.38	0.4
10.5	0.00	—0.3
11.5	0.56	0.1
12.5	0.25	0.4
13.5	0.14	0.4
14.5	0.58	0.7
Average	0.284	0.35

Both investigations agree that the girls surpass the boys on the average by about three-tenths of a year in mental age, but the superiority is irregularly distributed. It has been customary to see in these figures a more rapid mental maturation of girls to harmonize with their more precocious physical development, but even if this interpretation is correct—it is not altogether certain that it is—the significant matter is the closeness of the approximation of the two sexes to equality. As adults they are equal.

In more specific mental abilities—perception, memory, reason, etc.—the difference between the sexes, where they exist at all, are so slight and unobtrusive as to be swamped

by comparison with the immensity of the variation within either sex.

In special aptitudes for various types of school work, sex differences again appear to be slight. Using a battery of standardized tests for reading, vocabulary, arithmetic, spelling, composition, writing, drawing, and handwork, Burt has measured over 5000 school children in 19 different schools, yielding for each age approximately 750 representatives of each sex. The facts are given in the accompanying table which displays the relative attainments of each. On the whole, the differences are essentially negligible. Girls excel slightly in reading, spelling, writing, and composition; boys in arithmetic and handwork; in drawing the sexes are equal. How insignificant are the differences in general is disclosed by the data for arithmetic. In addition girls are slightly superior, in subtraction boys excel, in multiplication attainments are equal, and in division boys excel slightly. All through the list, the sexes play a veritable leap-frog with each other

THE AVERAGE SCORES FOR BOYS AND GIRLS OF THE SAME AVERAGE AGE

(From Burt)

	Reading Speed (Seconds)	*Reading Comprehension Questions Answered*	*Spelling Words Correct*	*Addition Number Correct*	*Subtraction Number Correct*	*Multiplication Number Correct*
Boys......	117 *	11.3	53.6	21.1	41.0	40.7
Girls......	112 *	11.6	56.4	21.4	39.7	40.9

	Division Number Correct	*Writing Letters in Two Minutes*	*Writing Quality*	*Drawing Quality*	*Handwork Speed (Seconds)*	*Handwork Quality*	*Composition Quality*
Boys.	29.9	117.2	9.8	10.0	54.6 *	10.8	10.6
Girls.	29.1	125.2	10.1	9.9	55.7 *	10.2	11.4

* Scores are given in terms of seconds—the smaller figure therefore indicates the better performance.

and even in handwork the differences are so small as to be statistically unreliable. On the whole, with equal incentives there is little justification for the assumption of sex differences in capacities for achievement in school functions.

Concerning sex differences in emotional, temperamental, moral, and other traits innumerable opinions have been given; but for none is there unquestionable evidence. Indeed, as more precise measurement becomes possible the verdict of "no significant difference" is most frequently cast, although it may be that in the traits as yet unmeasured important differences will be disclosed. The most probable differences are certain attitudes and emotional propensities clustering around the differences in the reproductive functions on the one hand, and the differences in physical powers on the other. It is believed by some, but not proved, that the maternal urges differ in strength and in operation from the paternal, resulting for the woman in a keener interest, broader sympathies, and perhaps clearer insight in dealing with human expressions and acts. Men may be more self-assertive and pugnacious, in keeping with their superior physical strength.

Differences in general achievement and personality between the sexes, then, in so far as environmental influences affect them equally, are doubtless exaggerated by the tendency to compare the extremes rather than the typical cases. The general differences which do obtain are to be explained not so much by differences in all single traits as by the influence of a few which color the whole. Thus, if the parental urges are stronger in women, it may affect widely their activities in and relations to life. The superior physical strength of men—and if genuine, the greater force of the pugnacious urges—would account in

part for their greater achievements, even if the mental and motor aptitudes of the sexes were equal.

Racial Differences.

Another opportunity to study combinations of traits is provided by the existence of different races. Indeed, it is and always has been customary to believe that each race has its peculiarly individual personality; that the Frenchman, Englishman, German or Swede is innately organized in a characteristic way; in a pattern that cannot be wholly rearranged by environment or training.

Among civilized races differences in physical traits are demonstrated; differences in temperamental traits are probable, but not demonstrated; and differences in mentality are neither demonstrated nor probable. Extensive measures by various forms of the Binet test in France, Germany, Sweden, England, and America, and less extensive investigation in other countries, show inconspicuous variations in general outcome. The probability is that the general mental ability of these races is approximately equal. In America, little has been learned of racial differences, except that on such tests as the Army Alpha, Negroes and Indians perform relatively poorly; but any sweeping statement of the intellectual status of these races would be premature. Among other races in America, in so far as traits have been measured, the overlapping is very great, both in physical and mental characteristics. Concerning emotional and temperamental traits, there is little to offer except conjecture. It is quite likely, however, that the tendency to seize upon some one or few peculiarities of a race, magnify them, and judge the whole personality in the light of them, results in an exaggeration of the differences between races as a whole.

The Correlation of Traits.

Our final problem is concerned with the character of the organization of different traits among individuals of the same sex and race. In the typical individual, what does superiority or inferiority in one trait *imply* concerning other traits? Does superiority in one respect indicate nothing at all concerning other characteristics, or does it imply inferiority or superiority in other traits? Such questions are answered by measuring a group of individuals and computing the coefficients of correlation which express the average or typical association of any one trait with another. If the correlation is zero, the one implies nothing concerning the other; if it is positive it indicates that the two tend, in degree indicated by the magnitude of the coefficient, to go together—a high, average, or low status in one implying a high, average or low status in the other; if the correlation is negative, superiority in one implies inferiority in the other or vice versa.

Studies of the correlations of human traits early disclosed the fallacy of the prevalent belief in compensation —the assumption that the possession of certain desirable traits implied the presence of compensating undesirable characteristics. To illustrate: it was frequently asserted that the quick learners retain poorly, that the rapid workers were inaccurate, that great knowledge went with slow wit, that men of great artistic abilities—as in music, painting or literary composition—were usually stupid in practical matters, that scholarly minds were encased in clumsy bodies, that superior intellects were usually coupled with inferior mental stability. To the extent that various desirable traits have been measured, the facts generally favor the theory of positive correlation rather

than that of negative correlation or compensation. If the reader will glance at the various tables of correlations in this book, he will find positive correlations almost exclusively. A few others will be briefly mentioned, taking as samples the correlations of various desirable traits with general mental ability.

Superiority in mental capacities is correlated positively but not closely with desirable physical traits. If we take

CORRELATIONS OF INTELLIGENCE QUOTIENTS AND VARIOUS TRAITS IN A GROUP OF 150 FIRST GRADE CHILDREN

(After Dickson quoted from Terman)

Trait	*Correlation with I.Q.*
Sense of humor	.58
Persistence	.53
Initiative	.53
Will power	.50
Conscientiousness	.48
Personal appearance	.44
Cheerfulness	.43
Physical self-control	.42
Courage	.39
Dependability	.38
Emotional self-control	.29
Unselfishness	.29
Speed	.28

a large group of individuals of the same age and divide them into two groups on the basis of mental ability, the brighter group will have fewer defects of the sense organs, nervous system, reacting mechanisms, and internal organs. There will be many exceptions to the general rule among individuals inasmuch as the correlations are usually low. A similar relation between mental ability and physiological efficiency will be found. The indications are that the group superior in mentality will surpass the other in re-

sistance to disease, to drugs such as alcohol, to malnutrition, to exposure, etc.

The correlations of general mental ability with the broader volitional, emotional, æsthetic, social, and temperamental traits are less well known chiefly because these traits have not as yet yielded to precise measurements. The list of correlations in the table on the preceding page, however, suggests a decided tendency toward positive correlation.

General mental ability, then, is positively associated more or less with other desirable traits. If the problem had been taken up from another point of view, such as the correlations of other traits with morality or artistic ability, the same *general* result would have been found, namely, all desirable traits tend to be associated with each other. The correlations are not equal, however, and they are often low. Even a correlation as high as $+ 0.90$ permits several individuals fairly high in one trait to be fairly low in the other, and vice versa. Specialization there is; we all have our particular strengths and weaknesses. But on the average, weakness in one trait implies weakness in others; mediocrity in one implies mediocrity in others, and strength in one, strength in others.

QUESTIONS AND EXERCISES

1. What is the difference between a *test* and a *standardized test?*
2. Which is probably more accurate, a rating on a *quality* or a rating on a *difficulty* scale? Why?
3. When we measure a man's height in his stocking feet, back against the wall, using an instrument to fit closely to the top of the head and recording the result in inches, what comprises the *test* and what the *scale?*
4. For purposes of examination, what advantages do you see in using the "True-False" and other tests suggested in the exercises of earlier chapters over the essay examinations? What dis-

advantages, if any? (For a report of the use of such tests in courses in psychology see an article by A. I. Gates in the *Journal of Educational Psychology*, May, 1921.)

5. What are some of the uses to which the Stenquist tests of mechanical aptitude could be put in industry and in school?
6. Do you recall evidence presented in the book which would indicate the desirability of supplementing or supplanting the judgment of the employment manager by objective tests of ability? As used in the army what were such tests termed?
7. What do people usually mean when they speak of a "womanly woman," "a manly man," "a true Irishman," "a typical Frenchman?" Do you know any such individuals? Are they typical or exceptional?
8. Why do we have less accurate measures for such traits as diligence, ambition, etc., than we have for intelligence? Are these traits more complex, intrinsically more difficult to measure, less important in life, or are there other causes? Draw up a list of possible explanations.
9. Have women accomplished as much as men in the fields of art, literature, or science? How do you account for any discrepancies found? What biological and environmental as well as psychological factors might be important?
10. Which will usually tell you most about an individual's mental equipment, a knowledge of his race or a knowledge of the traits of his parents?
11. Draw a curve of distribution which will show how we distort the facts when we assume that individuals are divided into types.
12. What traits, other than those mentioned in the text, do you think may contribute to success in school work or life? What ones to desirable moral adjustments? To musical ability? To dramatic ability? To executive ability?
13. Among your acquaintances, do desirable traits seem to go together? Try this out by rating them in several traits such as intelligence, personal appearance, health, popularity, and trustworthiness and compare the results with the distributions shown at the end of Chapter XVII. Is the correlation positive or negative?
14. To what practical uses, in education or elsewhere, may the facts of correlation among desirable traits be put? Do they make

measures of intelligence more or less significant than would be the case if the correlations among traits were nearly zero?

GENERAL REFERENCES

For the use of achievement tests in school see—W. S. Monroe, S. C. DeVoss and F. J. Kelley, *Educational Tests and Measurements*, Boston: Houghton Mifflin, 1917; J. C. Chapman and G. P. Rush, *Scientific Measurement of Classroom Products*, N. Y.: Silver, Burdett & Co., 1917; G. M. Wilson and S. K. Hoke, *How to Measure*, New York: Macmillan, 1921; W. A. McCall, *How to Measure in Education*, New York: Macmillan, 1922; S. L. and L. C. Pressey, *Introduction to the Use of Standard Tests*, Yonkers, N. Y.: World Book Co., 1922; V. E. Dickson, *Mental Tests and the Classroom Teacher*, Yonkers: World Book Co., 1923; M. R. Trabue, *Measuring Results in Education*, New York: American Book Co., 1924.

The use of trade tests in the army is described in J. C. Chapman, *Trade Tests*, New York: Henry Holt, 1921, and H. A. Toops, *Trade Tests in Education*, New York: Teachers College, 1921.

The use of tests in industry is treated in: H. Muensterberg, *Psychology and Industrial Efficiency*, Boston: Houghton Mifflin, 1913; H. C. Link, *Employment Psychology*, New York: Macmillan, 1919; W. D. Scott and M. H. Hayes, *Science and Common Sense in Working with Men*, New York: Ronald, 1921; W. D. Scott and R. C. Clothier, *Personnel Management*, Chicago: Shaw, 1923; A. W. Kornhauser and F. A. Kingsbury, *Psychological Tests in Business*, Chicago: University of Chicago Press, 1924.

The use of tests in studying delinquent and unstable children is treated in Florence Mateer, *The Unstable Child*, New York: Appleton, 1924.

For tests of special aptitudes and for vocational guidance see J. L. Stenquist, *Measurement of Mechanical Ability*, New York: Teachers College, 1923; C. E. Seashore, *The Psychology of Musical Talent*, Boston: Silver, Burdette, 1919; H. A. Toops, *Tests for Vocational Guidance of Children*, New York: Teachers College, 1923; H. C. McComas, *The Aviator*, New York: Dutton, 1922; L. S. Hollingworth, *Special Talents and Defects*, New York: Macmillan, 1923; H. L. Hollingworth, *Vocational Psychology*, New York: Appleton, 1916, and C. H. Griffitts, *Fundamentals of Vocational Psychology*, New York: Macmillan, 1924.

The Woodworth Psychoneurotic Questionnaire is printed in full

in H. L. Hollingworth, *The Psychology of Functional Neuroses,* New York: Appleton, 1920, Chapter 8.

Sections on the use of tests in studying nervous and mental disorders appear in A. J. Rosanoff, *Manual of Psychiatry,* New York: John Wiley & Son, 1920, Part I, Chapter 7, Part III, Chapters 6 and 7. Appendix VI is devoted to a discussion of, and includes, the Kent-Rosanoff association frequency tables. The frequencies obtained from children will be found in H. Woodrow and F. Lowell, *Children's Association Frequency Tables,* Princeton, N. J.: Psychological Monographs, No. 97, 1916.

Tests for various traits of character and temperament are described in H. L. Hollingworth, *Judging Human Character,* New York: Appleton, 1922, and June Downey, *The Will-Temperament and Its Testing,* Yonkers: World Book Co., 1923.

For tests of sensory, motor and miscellaneous mental abilities see G. M. Whipple, *Manual of Mental and Physical Tests,* 2 vols., Baltimore: Warwick and York, 1914, 1915, and S. I. Franz, *Handbook of Mental Examination Methods,* New York: Macmillan, second edition, 1919.

Sex and racial differences are treated in E. L. Thorndike, *Educational Psychology,* Vol. III, New York: Teachers College, 1914.

INDEX